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**Personal Narrative**  
**OF TRAVELS**  
 TO THE  
**EQUINOCTIAL REGIONS**  
 OF THE  
**NEW CONTINENT,**

DURING THE YEARS 1799—1804,

BY

ALEXANDER DE HUMBOLDT,

AND

AIMÉ BONPLAND;

WITH MAPS, PLANS, &c.

WRITTEN IN FRENCH BY

ALEXANDER DE HUMBOLDT,

AND TRANSLATED INTO ENGLISH BY

HELEN MARIA WILLIAMS.

VOLS. I & II.

Third Edition.

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# CONTENTS.

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## VOL. I.

---

### BOOK I.

#### CHAPTER I.

	PAGE
Preparations.—Instruments.—Departure from Spain.	
—Landing at the Canary Islands. . . . .	1

#### CHAPTER II.

Stay at Teneriffe.—Journey from Santa Cruz to Orotava.—Excursion to the top of the Peak of Teyde.	111
---	-----

---

## VOL. II.

---

#### CHAPTER III.

Passage from Teneriffe to the coasts of South America.	
—The Island of Tobago.—Arrival at Cumana.	1

### BOOK II.

#### CHAPTER IV.

First abode at Cumana.—Banks of the Manzanares.	175
---	-----

#### CHAPTER V.

Peninsula of Araya.—Salt-marshes.—Ruins of the Castle of San Giacomo. . . . .	232
---	-----



## PREFACE.

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AFTER having so long withdrawn myself from the public eye, it is only under the auspices of the following work, that I should have ventured to appear once more in its presence.

The narratives of travellers, and, above all, the description of those remote countries of the globe, which have immortalized the name of Cook, have always had a particular attraction for my mind; and led me in my early youth, to weave an humble chaplet for the brow of that great navigator, which my venerable friend, Doctor Kippis, inserted in the history of his life. The narrative of Cook's glorious



career derives a particular charm from presenting to us new systems of social organization ; but it must be admitted, that in general sea-expeditions have a certain monotony, which arises from the necessity of continually speaking of navigation in technical language. The mariner also, while he braves the element on which he steers his perilous course, is chiefly occupied by its dangers. The outlines and the bearings of coasts are the leading objects of his researches ; he visits only the shores of the countries where he disembarks, and holds but slight communications with the natives by whom they are peopled.

The history of journies by land in distant regions is far more calculated to excite general interest ; not only by extending the limits of science, but by presenting new aspects of the variegated scenery of the Globe. Happy the traveller, with whom the study of Nature has not

been merely the cold research of the understanding, in the explanation of her properties, or the solution of her problems! who, while he has interpreted her laws, has adored her sublimity, and followed her steps with passionate enthusiasm, amidst that solemn and stupendous scenery, those melancholy and sacred solitudes, where she speaks in a voice so well understood by the mysterious sympathy of the feeling heart. With what soothing emotions, what eager delight, do we follow the traveller, who leads us from the cares, the sorrows, the joys of ordinary life, to wander in another hemisphere! to mark unknown forms of luxuriant beauty, and unknown objects of majestic greatness—to view a new earth, and even new skies! from which the stars known from childhood, the stars of home, have disappeared, and are succeeded by a foreign firmament. How often will posterity also turn from the terrible page of our history, to repose

on the charm of a narrative, which displays the most enlarged views of science and philanthropy! What sympathy does the traveller excite, while he imprints the first step, that leads to civilization and all its boundless blessings, along the trackless desert, and, struggling with the savageness of the untamed wilderness, obtains a victory that belongs to mankind.

It were erroneous to believe, that countries, because they have been already visited, are therefore known. A penetrating and capacious mind finds every where new materials for observation. The work, of which I now offer the translation to the public, relates to regions of which the greater part have never till now been described by a scientific and learned traveller. A few botanists had indeed herbalized along those distant coasts, and added some riches to the vegetable world. La Condamine, Don Jorge Juan, and Bouguer, scaled the lofty Andes ; but it was only to



measure their height, and make astronomical observations. Their journals, which date farther back than half a century, were written when geology did not exist as a science, and the physical structure of those giants of our Globe was yet unknown.

What has hitherto been wanting is now accomplished. M. de Humboldt has in this work displayed, more than in any other he has yet published, his peculiar manner of contemplating nature in all her overwhelming greatness. The appropriate character of his writings is the faculty he possesses of raising the mind to general ideas, without neglecting individual facts ; and while he appears only to address himself to our reason, he has the secret of awakening the imagination, and of being understood by the heart.

The general picture, which he has drawn of the Isle of Teneriffe, and the geography of it's plants, proves, that in objects often

viewed by others he has seen what they had failed to discern ; and in almost the whole of the remainder of his travels he pursues alone the difficult path of scientific discovery. From the Canary Islands he passes to Cumana, New Andalusia, and the missions of the Indians, Chaymas, the province of the Caraccas, the banks of the Apure and the Rio Negro, to the limits of Brazil, New Grenada, the Andes of Popayan, Porto, Quito, and Peru, the western part of the Amazons, Mexico, and the Isle of Cuba. How majestic is nature in the forest and on the banks of the Oroonoko ! the communications of which flood with that of the Amazons M. de Humboldt has astronomically laid down and determined.

This great work will now soon be terminated. M. de Humboldt remains in Paris for this purpose, with the permission of his own government.

In becoming his interpreter in the text

of the Picturesque Atlas, and the Personal Narrative of his voyage, I have been encouraged by the care with which he has read most of my pages, and corrected many of my errors. My scanty knowledge of the first principles of science seemed indeed to preclude the full comprehension of many of the subjects of which he treats ; but a short experience convinced me, that what is clearly expressed may be clearly understood ; and I shall perhaps be pardoned, if, from the novelty of the subject, neologisms sometimes occur. Long a stranger to my country, I have indeed no critical favor to expect ; I mean that species of favor, which arises from personal acquaintance, and, perhaps even unknowing to the critic himself, softens the stern brow of reproof, and leads him unconsciously to be indulgent, when he only meant to be just. I have nothing to hope from such predilection. My literary patrons belonged to what Ossian calls “ the days



of other years." Above all, the learned protector of my early pen, he, whom I have already mentioned, and of whom I never think without emotion, is long since no more ! But in appearing before an English tribunal, I will not fear injustice, if I have nothing to hope from partiality ; and whatever may be the fate of my imperfect copy of a sublime model, I shall never feel, that the moments were mispent, which I have employed in so soothing, and so noble a task.

HELEN MARIA WILLIAMS.

## INTRODUCTION.

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**T**WELVE years have elapsed since I quitted Europe, to examine the interior of the new continent. Devoted from my earliest youth to the study of nature, feeling with enthusiasm the savage beauties of a country guarded by mountains, and shaded by ancient forests, I experienced in my travels such enjoyments, as have amply compensated for the privations inseparable from a laborious, and often agitated life. These enjoyments, which I endeavoured to impart to my readers in my Remarks upon the Steppes, and in the Essay on the Physiognomy of Plants, were not the only fruits I have reaped from an undertaking, formed with the design of contributing to the progress of natural philosophy. I had long prepared myself for these observations which were the principal objects of my

voyage to the torrid zone. I was provided with instruments of easy and convenient use, constructed by artists of the highest reputation ; and I enjoyed the special protection of a government, which, far from presenting obstacles to my investigations, constantly honoured me with every mark of regard and confidence. I was aided by a courageous and enlightened friend, and, what is singularly propitious to the success of participated labour, whose zeal and equanimity never failed, amidst the fatigues and dangers to which we were sometimes exposed.

Under such favorable circumstances, traversing regions which for ages have remained almost unknown to the greatest part of the nations of Europe, I might add even to Spain, we have collected, Mr. Bonpland and myself, a considerable number of materials, the publication of which may throw some light on the history of nations, and the knowledge of nature. Our inquiries having been directed towards a great variety of objects, we have been unable to present the result under the common form of an itinerary, and have there-



fore consigned our observations in a series of separate works, compiled in the same view, and connected with each other by the nature of the phenomena which they explain. This sort of composition betrays more readily the imperfection of partial labors, and therefore is unfavorable to the self-love of the traveller ; but it is highly preferable for whatever relates to the physical and mathematical sciences, because the different branches of those sciences are seldom cultivated by the same class of readers.

I had in view a double purpose in the travels, of which I now publish the historical narrative. I wished to make known the countries I had visited ; and to collect such facts as are fitted to elucidate a science, of which we have possessed scarcely the outline, and which has been vaguely denominated *natural history of the world*, *theory of the Earth*, or *physical geography*. The last of these two objects seemed to me the most important. I was passionately devoted to botany, and certain parts of zoology, and I flattered myself that our investigations might add some new species

to those which have been already described; but preferring the connection of facts, which have been long observed, to the knowledge of insulated facts, although they were new, the discovery of an unknown genus seemed to me far less interesting than an observation on the geographical relations of the vegetable world, on the migration of the *social* plants, and the limit of the height which their different tribes attain on the flanks of the Cordilleras.

The natural sciences are connected by the same ties that link all the phenomena of nature. The classification of the species which we ought to consider as the fundamental part of botany, and the study of which is become more attractive and more easy by the introduction of natural methods, is to the geography of plants, what descriptive mineralogy is to the indication of the rocks which constitute the exterior crust of the globe. To comprehend the laws which are observed in the position of these rocks, and determine the age of their successive formations, and their identity in the most distant regions, the geologist ought to be

previously acquainted with the simple fossils, which compose the mass of mountains, and of which the names and character are the object of oryctognostical knowledge. It is the same with that part of the natural history of the globe, that treats of the relations the plants have to each other, with the soil whence they spring, or the air which they inhale and modify. The progress of the geography of plants depends in a great measure on that of descriptive botany; and it would be injurious to the advancement of the sciences to attempt rising to general ideas, in neglecting the knowledge of particular facts.

I have been guided by these considerations in the course of my inquiries; they were always present to my mind at the period of my preparatory studies. When I began to read the numerous relations of voyages, which compose so interesting a part of modern literature, I regretted that travellers, the most enlightened in the insulated branches of natural history, were seldom possessed of a sufficient variety of knowledge, to avail themselves of every advantage arising from their position. It ap-

peared to me, that the importance of the results hitherto obtained did not keep pace with the immense progress, which several parts of science, and particularly geology, the history of the modifications of the atmosphere, and the physiology of animals and plants, had made at the end of the eighteenth century. I saw with regret, and all scientific men have shared this sentiment, that whilst the number of accurate instruments was daily increasing, we were still ignorant of the height of so many mountains and elevated plains; of the periodical oscillations of the aerial ocean; the limit of perpetual snows under the polar circle, and on the borders of the torrid zone; the variable intensity of the magnetic forces, and so many other phenomena, equally important.

Maritime expeditions, voyages round the world, have conferred just celebrity on the names of those naturalists and astronomers, who have been appointed by governments to encounter the dangers they present; but while those distinguished persons have given precise notions of the external configuration of countries, of the



natural history of the ocean, and of the productions of islands and coasts, their expeditions seem less fitted to advance the progress of geology, and other parts of general physics, than travels into the interior of a continent. The advancement of the natural sciences has been subordinate to that of geography and nautical astronomy. During a navigation of several years, the land but seldom presents itself to the observation of the mariner ; and when, after lengthened expectation, it is descried, he often finds it stripped of it's most beautiful productions. Sometimes beyond a barren coast he perceives a ridge of mountains covered with verdure, but it's distance forbids his examination, and the view serves only to increase his regrets.

Journeys by land are attended with considerable difficulty in the carriage of instruments and collections ; but these difficulties are compensated by real advantages, which it would be useless to enumerate. It is not by sailing along the coast, that we can discover the direction of the chains of mountains, and their geological constitution, the climate of each zone, and it's in-

fluence on the forms and the habits of organized beings. In proportion to the breadth of the continents, the greater is the display on the surface of the soil, of the richness of the animal and vegetable productions ; the more distant the central chain of mountains from the shores of the ocean, the greater variety we find, in the bosom of the earth, of those stony strata, the regular succession of which unfolds to us the history of our planet. In the same manner, as every being considered apart is impressed with a particular type, we find the same impression in the arrangement of brute matter organized in rocks, in the distribution and mutual relations of plants and animals. The great problem of the physical description of the globe, is the determination of the form of these types, the laws of their relations with each other, and the eternal ties which link the phenomena of life, and those of inanimate nature.

In explaining the motives which engaged me to undertake an expedition into the interior of a continent, I merely state the general direction of my ideas at an age

when we have not obtained a just estimate of our faculties. The plans of my early youth have been very incompletely executed. My journey has not had all the extent, which I proposed when I sailed for South America; nor has it furnished the number of general results which I had hoped to obtain. The court of Madrid had granted me in 1799 permission to embark on board the galleon of Acapulco, and visit the Marian and Philippine Islands, after traversing the colonies of the new continent. I had then purposed to go back to Europe by the great Archipelago of Asia, the Persian Gulf, and the way of Bagdad. I shall find occasion hereafter to state the reasons, which determined me to hasten my return. With respect to the works which Mr. Bonpland and myself have published, we hope that their imperfection, of which we are conscious, will be attributed neither to a want of zeal during the progress of our researches, nor to precipitation in the publication of our labors. A determined will and active perseverance are not always sufficient to surmount every obstacle.

Having stated the general object I had in view in my expeditions, I shall hasten to give a slight sketch of the whole of the collections and observations which we have accumulated, and the union of which is the aim and end of every scientific journey. The maritime war, during our abode in America, having rendered the communications with Europe very uncertain, we found ourselves compelled, in order to diminish the chance of losses, to form three different collections. Of these, the first was embarked for Spain and France, the second for the United States and England, and the third, which was the most considerable, remained almost constantly under our eyes. Towards the close of our expedition, this last collection formed forty two boxes, containing an herbal of six thousand equinoctial plants, seeds\*, shells,

\* Among the plants which we have introduced into the different gardens of Europe, I shall cite here, as worthy the attention of botanists, the following species. *Lobelia fulgens*, *l. splendens*, *caldasia heterophylla*, (*bonplandia geminiflora*, Cav.), *maurandia antirrhiniflora*, *gyrocarpus americana*, Jacq., *cæsalpinia cassioides*, *salvia cæsia*, *cyperus nodosus*, fa-



insects, and, what had hitherto never been brought to Europe, geological specimens from the Chimborazo, New Grenada, and the banks of the river of the Amazons.

After the journey to the Oroonoko, we left a part of these objects at the island of Cuba, in order to take them on our return from Peru to Mexico. The rest followed us during the space of five years, on the chain of the Andes, across New Spain, from the shores of the Pacific Ocean to the West Indian seas. The conveyance of these objects, and the minute care they required, occasioned us such embarrassments as would scarcely be conceived, by those even who

*gara lentiscifolia*, *heliotropium chenopodioides*, *convolvulus bogotensis*, *c. arborescens*, *ipomœa longiflora*, *solanum Humboldti*, Willd., *dichondra argentea*, *pitcairnia*, *furfuracea*, *cassia pendula*, *c. mollissima*, *c. prostrata*, *c. cuspidata*, *euphorbia Humboldti*, Willd., *ruellia foetida*, *sisyrinchium tenuifolium*, *sida cornuta*, *s. triangularis*, *phaseolus heterophyllus*, *glycine precatoria*, *g. sagittata*, *palea bicolor*, *psoralea divaricata*, *myrica mexicana*, *atriplex linifolia*, *inga microphylla*, *acacia diptera*, *a. flexuosa*, *a. patula*, *a. brachyacantha*, *a. ciliata*, *a. acicularis*, *a. peruviana*, *a. edulis*, and several varieties of *georgines*. (See *Willdenow Enum. plant. hort. Berol.* 1809.)

have traversed the most uncultivated parts of Europe. Our progress was often retarded by the threefold necessity of dragging after us, during expeditions of five or six months, twelve, fifteen, and sometimes more than twenty loaded mules, exchanging these animals every eight or ten days, and superintending the Indians who were employed in leading so numerous a caravan. Often, in order to add to our collections of new mineral substances\*, we

\* The mineral and vegetable substances which we have brought from America, several of which were till then unknown, have been submitted to chemical analysis by M. M. Vauquelin, Klaproth, Descotils, Allen, and Drapier, who have given descriptions of them in separate memoirs. I shall here mention two new mineral *species*: The feuer-opal, or quartz resinite miellé of Mexico (*Klaproth, chem. Unters. der Min. T. iv, p. 156. Sonneschmidt Beschr. der Mex. Bergref. S 119. Karsten min. Tabellen, 1808, p. 26, 88.*) and the conchoidal muriated silver of Peru, muschliches hornersz (*Klapr. IV, 10. Karst, p. 60, 97. Magazin der Berl. Naturf. I, 158*); the silver ore, *paco* of Pasco (*Klapr. IV.*) the antimonial gray copper ore, *graugultigerz* of Tasco (*Kl. IV, 74.*); the meteoric iron, *meteoreisen*, of Durango, (*Kl. IV, 101*); the ferriferous carbonated limestone, *stænglicher braunspath*, of Guanaxuato, the crystals of which reunited in bars form equilateral triangles (*Kl. IV,*

found ourselves obliged to throw away others, which we had collected a considerable time before. These sacrifices were not less painful than the losses which we accidentally made. Sad experience taught us but too late, that from the sultry humidity of the climate, and the frequent falls of the beasts of burden, we could preserve nei-

199); the obsidians of the Knife mountain of Moran, and the pierre perlée, perlstein of Cinapecuaro (*Descotils, Annales de Chimie, LIII, 260*); concrete oxidated tin, (wood tin) of Mexico (*Descotils, Ann. LIII, 266*); the brown lead-ore of Zimapan (*Descotils, Ann. LIII, 268*); the celestine of Popayan and the wavellite, or hydrargillite; a pepite of platina of Choco, weighing 1088·8 grains, which is 18·947 specific gravity (*Karsten, 96*); the moya of Pelileo, a volcanic combustible substance, containing feldspath (*Klap. IV, 289*); the guano of the islands of Peru, containing urat of ammonia (*Klapr. IV, 299. Fourcroy et Vauquelin, Mem. of the Inst. VI, 369*); the dapiché of the river Temi, a species of white caoutchouc, which is found at the depth of three or four feet in a damp soil (*Allen, Journ. Phys. Liv. XVII. 77*); the tabasheer of the bamboos of America, different from that of Asia (*Vauquelin, Mem. de l'Institut. VI, 382*); the cortex Angusturæ, bark of the bonplandia trifoliata of Carony; the cinchona condaminea of Loxa, and several other species of cinchona, which we collected in the forests of New Grenada (*Vauquelin, Ann. LIX, 137*).

ther the skins of animals too hastily prepared, nor the fishes and reptiles placed in phials filled with alcohol. I have thought proper to enter into these details, which, although little interesting in themselves, prove that we had no means of bringing back, in their natural state, many objects of zoology and comparative anatomy, of which we have published descriptions and drawings. Notwithstanding some obstacles, and the expense occasioned by the carriage of these articles, I had reason to applaud the resolution I had taken before my departure, of sending to Europe the duplicates only of the productions we had collected. I cannot too often repeat, that when the seas are infested with privateers, a traveller can be sure only of the objects in his own possession. A very small number of the duplicates, which we shipped for the ancient continent during our abode in America, were saved; the greater part fell into the hands of persons unknown to science. When a ship is condemned in a foreign port, boxes containing only dried plants or stones, far from being sent to the scientific men to whom they are addressed,



remain consigned to oblivion. Some of our geological collections taken in the Southern Ocean had, however, a happier fate. We were indebted for their preservation to the generous activity of Sir Joseph Banks, President of the Royal Society of London, who, amidst the political agitations of Europe, has unceasingly labored to strengthen the ties by which are united the scientific of all nations.

The same causes which checked our communications, have contributed also to form numerous obstacles, since our return, to the publication of a work, which from it's nature must be accompanied by a considerable number of engravings and maps. If such difficulties are sometimes encountered in undertakings made at the expense, and by the munificence of governments, how much more must they be felt by private individuals! It would have been impossible for us to have surmounted them, if the liberal zeal of the editors had not been seconded by the extreme favor of the public. More than two thirds of our work are already published. The maps of the Oroonoko, of the Cassiquiare, and of the

river Magdalena, founded on my astronomical observations, together with several hundred plants, are engraved and ready to appear. I shall not leave Europe to undertake an expedition into Asia, till I have laid before the public the whole result of my travels in the New Continent.

In the memoirs in which we have investigated the various objects of our remarks, we have considered each phenomenon under different aspects, and classed our observations according to the relations which they bear to each other. To give a just idea of the method we have followed, I shall here add a succinct enumeration of the materials, with which we were furnished for describing the volcanoes of Antisana and Pichincha, as well as that of Jorullo, which in the night of the 20th of September 1759, rose from the earth one thousand five hundred and seventy-eight French feet above the surrounding plains of Mexico. The positions of these singular mountains in longitude and latitude was ascertained by astronomical observations. We took the heights of the different parts by the aid of the barometer, and determined the dip

of the needle and the intensity of the magnetic forces. Our collections contain the plants which are spread on the flanks of these volcanoes ; and specimens of different rocks, which, piled on each other, constitute their external coat. We are enabled to indicate by measures sufficiently exact the height above the level of the ocean, at which we found each group of plants, and each volcanic rock. Our journals furnish us with a series of observations on the humidity, the temperature, the electricity, and the degree of the transparency of the air on the brinks of the craters of Pichincha and Jorullo; the topographical plans and the geological profiles of these mountains, founded in part on the measure of vertical bases, and on angles of altitude. Each observation has been calculated according to the tables and the methods, which are considered as the most exact in the actual state of our knowledge ; and in order to judge of the degree of confidence which the results may claim, we have preserved the whole detail of our partial operations.

It would have been possible to blend

these different materials in a work devoted wholly to the descriptions of the volcanoes of Peru and New Spain. Had I given the physical description of a single province, I could have treated separately what relates to geography, mineralogy, and botany ; but how could I interrupt either the narrative, a disquisition on the manners, the aspect of nature, or the great phenomena of general physics, by the fatiguing enumeration of the productions of the country, the description of new species of animals and plants, or by the dry detail of astronomical observations ? Had I adopted a mode of composition, which should have contained in the same chapter all that has been observed on the same point of the globe, I should have composed a work of cumbrous length, and devoid of that clearness, which arises in a great measure from the methodical distribution of the matter. Notwithstanding the efforts which I have made to avoid, in this narration of my journey, the errors I had to dread, I feel conscious, that I have not always succeeded in separating the observations of detail from those general consequences, which interest every en-



lightened mind. These results comprise in one view the climate, and it's influence on organized beings, the aspect of the country, varied according to the nature of the soil and it's vegetable covering, the direction of the mountains, and the rivers which separate the races of men as well as the tribes of vegetables; and finally, those modifications, which the state of nations, placed in different latitudes, and in circumstances more or less favorable to the display of their faculties undergoes. I am not afraid of having too much enlarged on objects so worthy of attention: one of the noblest privileges, which distinguish modern civilization from that of remoter times, is the having enlarged the mass of our conceptions, having rendered us more capable of perceiving the connection between the physical and intellectual world, and having thrown a more general interest over objects, which heretofore occupied only a small number of scientific men, because these objects were contemplated separately, and from a narrower point of view.

It is probable that the volumes, which I am now about to publish, will fix the atten-

tion of a greater number of readers than the detail of observations merely scientific, or than my researches on the population, the commerce, and the mines of New Spain. I may therefore be permitted to enumerate in this place all that we have hitherto published. When several works are interwoven in some sort with each other, it may perhaps be interesting to the reader, to know the sources from which he may obtain more circumstantial information. In the journey of Pallas, which is so remarkable for the precision and depth of his researches, the same Atlas contains geographical maps, the costumes of different nations, relicks of antiquity, and figures of plants and animals. In conformity to the plan of our work, we have distributed these plates into distinct parts; having divided them into the two geographical and physical Atlases, which belong to the narrative of the travels, and the Political Essay on the Kingdom of New Spain; the Views of the Cordilleras, and the monuments of the natives of America; and the Equinoctial Plants, the Monography of the Melastomas, and the Collection of zoological observations.

As I shall often be obliged to cite these different works, I shall mention in notes the abbreviations, which I have used to indicate the titles.

I. *Astronomical observations, trigonometrical operations and barometrical measurements made during the course of a journey to the equinoctial regions of the New Continent* \* from 1799 to 1804. This work, to which are added historical researches on the position of several points important to navigators, contains, first, the original observations which I made from the  $12^{\circ}$  of southern, to the  $41^{\circ}$  of northern latitude; the transits of the sun and stars over the meridian; distances of the moon from the sun and the stars; occultations of the satellites; eclipses of the sun and moon; transits of mercury over the disk of the sun; azimuths;

\* *Astron. Observations*, two volumes in 4to. I have discussed in the introduction, placed at the head of this work, the choice of the most proper instruments to employ in distant journies, the degree of precision that can be obtained in the different kinds of observations, the peculiar motions of certain great stars of the southern hemisphere, and several methods, the use of which is not sufficiently common among navigators.

circum-meridian altitudes of the moon, to determine the longitude by the differences of the declination ; researches on the relative intensity of the light of the austral stars ; geodesical measures, &c. Secondly, a treatise on the astronomical refractions under the torrid zone, considered as the effect of the decrement of caloric in the strata of the air ; thirdly, the barometric measurement of the Cordillera of the Andes, of Mexico, of the province of Venezuela, of the kingdom of Quito, and of New Grenada ; followed by geological observations, and containing the indication of four hundred and fifty-three heights, calculated, according to the method of Mr. Laplace, and the new coefficient of Mr. Ramond ; fourthly, a table of near seven hundred geographical positions on the New Continent ; two hundred and thirty-five of which have been determined by my own observations, according to the three coordinates of longitude, latitude, and height.

II. *Equinoctial plants collected in Mexico, in the Isle of Cuba, in the provinces of Caraccas, Cumana, and Barcelona, on the Andes of New Grenada, Quito, and Peru,*



*and on the banks of the Rio Negro, the Oroonoko, and the river of Amazons* \*.

Mr. Bonpland has given the figures of more than forty new genera † of plants of the torrid zone, classed according to their natural families. The methodical descriptions of the species are both in French and in Latin, and accompanied by observations on the medicinal properties of the plants, on their use in the arts, and on the climate of the countries where they are found.

III. *Monography of the Melastomas, rhexia, and other genera of this order of plants* ‡. This work will comprise upwards of a

\* Equinoctial plants, 2 vols. folio, with more than 120 plates. This number of plates has been greatly augmented since M. de Humboldt wrote this introduction. The number contained in the two volumes will exceed 150. See the prospectus of M. de Humboldt's works, at the end of the volume.

† We shall cite here only the genera, ceroxylon, marathrum, cassupa, saccellium, cheirostemon, retiniphyllum, machaonia, limnocharis, bertholetia, exostema, vauquelinia, guardiola, turpinia, salpianthus, hermesia, cladostyles, lilæa, calcitium, espeletia, bonplandia, platycarpum, andromachia, menodora, gaylussaica, podopterus, leucophyllum, angelonia.

‡ Melastomas, 2 vols. folio, with colored plates.

hundred and fifty species of melastomacea, which we collected during the course of our expeditions, and which form one of the most beautiful ornaments of tropical vegetation. Mr. Bonpland has added the plants of the same family, which, among so many other rich stores of natural history, Mr. Richard collected in his interesting expedition to the Antilles and French Guiana, and of which he has communicated to us the descriptions.

IV. *Essay on the geography of plants, accompanied with a physical table of the equinoctial regions, founded on measures taken from the tenth degree of northern to the tenth degree of southern latitude* \*.

I have endeavoured to collect under a single point of view the whole of the physical phenomena of that part of the New Continent, comprised in the torrid zone, from the level of the South Sea to the highest summit of the Andes ; namely, the

\* This work, printed for the first time in 1806, will be reprinted with additions, and form part of the fifth division of the complete collection, under the title of *General Physics*. I have explained the first ideas of the *geography of plants*, their *natural associations*, and the *history of their migrations*, in my *Flora*, &c.

vegetation, the animals, the geological facts, the cultivation of the soil, the temperature of the air, the limit of the perpetual snows, the chemical constitution of the atmosphere, it's electrical intensity, it's barometrical pressure, the decrement of gravitation, the intensity of the azure color of the sky, the diminution of the light during it's passage through the successive strata of the air, the horizontal refractions, and the heat of boiling water at different heights. Fourteen scales, disposed at the side of a profile of the Andes, indicate the modifications which these phenomena undergo from the influence of the elevation of the soil above the level of the ocean. Each group of plants is placed at the height that nature has assigned, and we may follow the prodigious variety of their forms, from the region of the palms and the fern-trees to those of the johannesia (chuquiraga, Juss.) the gramineous plants, and lichens. These regions form the natural divisions of the vegetable empire; and in the same manner as the perpetual snows are found in every climate at a determinate height, the febrifuge species of the quinquina

(cinchona) have also their fixed limits, which I have marked in the botanical chart belonging to this essay.

V. *Collection of observations on zoology and comparative anatomy* \*. I have comprised in this work the history of the condor; experiments on the electrical action of the gymnotus †; a treatise on the larynx of the crocodiles, the quadrumani, and birds of the tropics; the description of several new species of reptiles, fishes, birds, monkeys, and other mammalia but little known. A distinguished man of science, whose constant friendship has been highly honorable and advantageous to me during a great number of years, Mr. Cuvier, has enriched the collection with a very extensive treatise on the axolotl of the lake of Mexico, and on the genera of

\* *Zoolog. Obs.* two vols, in 4to. The first of these volumes is published with thirty plates, most of which are colored. The second volume is far advanced.

† These experiments are connected with those I published previous to my departure to America, in the second volume of my essay on the irritability of the nervous and muscular fibre, and on the chemical action which keeps up the life of animals and plants.  
1796.



the protei in general. This naturalist has also recognized two new species of mastodontes, and a real elephant, among the fossil bones of quadrupeds which we brought from America \*. The description of the insects collected by Mr. Bonpland is due to Mr. Latreille, whose labours have so much contributed to the progress of entomology in our times. The second volume of this work will contain the figures of the Mexican, Peruvian, and Aturian skulls, which we have deposited in the Museum of Natural History at Paris, and on which Mr. Blumenbach has already published observations in the *Decas quinta craniorum diversarum gentium*.

VI. *Political essay on the kingdom of New Spain, with a physical and geographical atlas, founded on astronomical observations, and trigonometrical and barometrical measurement* †. This work, found-

\* Ann. of the Museum of Nat. Hist. t. viii, p. 57, and pp. 412, 413, pl. 2, figs. 1, 5.

† *Polit. Ess. &c.* in two vols, in 4to, and an Atlas of twenty charts in folio. My general map of the kingdom of New Spain, formed on astronomical observations, and on the whole of the materials which existed in Mexico in 1804, has been copied by Mr.

ed on a great number of official memoirs, presents, in six divisions, considerations on the extent and natural appearance of Mexico, on the population, on the manners of the inhabitants, their ancient civilization, and the political division of their territory. It embraces at the same time the agriculture, the mineral riches, the manufactures, the commerce, the finances, and the military defence of this vast coun-

Arrowsmith, who has appropriated it to himself, by publishing it on a larger scale, under the title of *New Map of Mexico, compiled from original Documents, by Arrowsmith*. It is very easy to recognize this map from the number of chalcographical errors with which it abounds, from the explanation of the signs which he has forgotten to translate from the French into English, and from the word *ocean*, which is engraved amidst the mountains, in a place where the original states, that *the elevated plain of Toluca is 1400 toises above the level of the ocean*. The conduct of Mr. Arrowsmith is so much the more reprehensible, as neither Messers. Dalrymple, Rennel, D'Arcy de la Rochette, nor any of those other excellent geographers England boasts, have ever given him the example, either in their maps, or the analyses which accompany them. The reclamations of a traveller must appear just, when mere copies of his labors are published under the names of other persons.

try. In treating on these different objects of political economy, I have endeavoured to consider them under a general point of view: I have drawn the parallel of New Spain, not only with the other Spanish colonies, and the confederation of the United States of North America, but also with the possessions of the English in Asia; I have compared the agriculture of the countries situate under the torrid zone, with that of the temperate climates; and I have examined the quantity of colonial produce necessary to Europe in the present state of it's civilization. In tracing the geognostic description of the districts of the richest mines of Mexico, I have given a statement of the mineral produce, the population, the imports, and exports, of the whole of Spanish America; I have, upon the whole, examined several questions, which, for want of precise data, had never hitherto been treated with the importance which they demand; such as those on the influx and reflux of metals \*, on their

\* The recent travels of Major Zebulon Montgomery Pike, in the northern provinces of Mexico, (*Account of the Expedition to the sources of the Mis*

progressive accumulation in Europe and Asia, and on the quantity of gold and silver, which, since the discovery of America down to our own times, the old world has received from the new. The geographical

*sisippi, and to the interior Parts of New Spain, Philadelphia, 1810*) contains valuable notions on the rivers La Platte and Arkansas, as well as on the chain of mountains which extends to the North of New Mexico, towards the sources of these two rivers : but the numerous statistical data, which Mr. Pike has collected in a country of the language of which he was ignorant, are for the greater part very inaccurate. According to this author, the mint of Mexico coins every year 50 millions of piastres in silver, and 14 millions in gold : while it is proved by the tables annually printed by order of the Court, and published in the Political Essay, that, the year in which the produce of the mines was the most abundant, the coinage amounted only to 25,806,074 piastres in silver, and to 1,359,814 piastres in gold. Mr. Pike displayed admirable courage in an important undertaking for the investigation of western Louisiana ; but, unprovided with instruments, and strictly watched on the road from Santa Fe to Natchitoches, he could do nothing towards the progress of the geography of the *provincias internas*. The maps of Mexico, which are annexed to the narrative of his journey, are reduced from my great map of New Spain, of which I left a copy, in 1804, at the secretary of states's office at Washington.



introduction at the beginning of this work contains the analysis of the materials, which have been used in the construction of the Mexican Atlas.

VII. *Views of the Cordilleras, and monuments of the indigenous nations of the new continent* \*. This work is meant to display a few of the great scenes of nature in the lofty chain of the Andes, and at the same time throw some light on the ancient civilization of the Americans, from the study of their monuments of architecture, their hieroglyphics, their religious rites, and their astrological reveries. I have given in this work a description of the teocalli, or Mexican pyramids, compared with that of the temple of Belus; the arabesques which cover the ruins of Mitla, idols in basalt, ornamented with the calantica of the heads of Isis; and a considerable number of symbolical paintings, representing the serpent woman, who is the Mexican Eve:

\* *Monum. Amer.* one vol. in folio, with 60 plates, part of which are colored, accompanied by explanatory treatises. This work may be considered as the picturesque Atlas to the historical narrative of the voyage.

the deluge of Coxcox, and the first migrations of the natives of the Azteck race. I have endeavoured to prove the striking analogies which exist between the calendar of the Toltecks, and the catasterisms of their zodiac, and the division of time of the people of Tartary and Thibet; as well as the Mexican traditions on the four regenerations of the globe, the pralayas of the Hindoos, and the four ages of Hesiod. I have also included in this work, in addition to the hieroglyphical paintings I brought back to Europe, fragments of all the Azteck manuscripts, which are found at Rome, Veletri, Vienna, and Dresden, and of which the last reminds us, by its lineary symbols, of the kouas of the Chinese. Together with the rude monuments of the natives of America, the same volume contains picturesque views of the mountainous countries, which these people have inhabited; such as those of the cataract of Tequendama, of Chimborazo, of the volcano of Jorullo, and of Cayambe, the pyramidal summit of which, covered with perennial ice, is situate directly under the equinoctial line. In every zone

the configuration of the ground, the physiognomy of the plants, and the aspect of a smiling or savage nature, have great influence on the progress of the arts, and on the style which distinguishes their productions; and this influence is so much the more perceptible, as man is farther removed from civilization.

I could have added to this work researches on the character of languages, which are the most durable monuments of nations. I have collected a number of materials on those of America, of which Messrs. Frederic Schlegel and Vater have made use: the first in his *Considerations on the Hindoos*, the second in his continuation of the *Mithridates* of Adelung, in the *Ethnographical Magazine*, and in his *Inquiries into the Population of the New Continent*. These materials are now in the hands of my brother, M. William de Humboldt, who, during his journey in Spain, and a long abode at Rome, formed the richest collection of American vocabularies, that has ever existed. His knowledge of the ancient and modern languages being very extensive, he has made some

curious approximations on this object, so important for the philosophical study of the history of man. I flatter myself, that a part of his labors will find a place in this narrative.

Of those different works which I have here enumerated, the second and third were composed by Mr. Bonpland, from the observations which he made on the spot, in a botanical journal. This journal contains more than four thousand methodical descriptions of equinoctial plants, a ninth part only of which have been made by me, and will appear in a separate publication, under the title of *Nova Genera et Species Plantarum*. In this work will be found not only the new species which we collected, and the number of which, after a long examination by one of the first botanists of the age, Prof. Willdenow, amounts to fourteen or fifteen hundred\*, but also the interesting observations made

\* A considerable part of these species is already inserted in the second division of the fourth part of the *Species Plantarum* of Linnæus, fourth edition. Of the eringiums, which we brought over from America, eleven new species have been engraved in the



by Mr. Bonpland, on the plants which have hitherto been imperfectly described. The plates of this work will be engraved and executed according to the method followed by Mr. Labillardiere, in the *Specimen Plantarum Novæ Hollandiæ*, which is a model of sagacity in research, and order in compilation.

The astronomical, geodesical, and barometric observations, have been calculated in a uniform manner, by employing correspondent observations, and according to tables of the utmost precision, by Mr. Oltmanns, professor of astronomy, and member of the academy of Berlin; who undertook the publication of my astronomical journal, which he has enriched with the results of his inquiries concerning the geography of America, the observations of Spanish, French, and English travellers, and the choice of the methods used by astronomers. I had calculated, during the course of my journey, two-thirds of my own observations, a part of the results of which

beautiful monography of this genus, published by Mr. de la Roche,

had been published previous to my return, in the *Connaissance des Temps*, and in the *Ephemerides* of Baron Zach. The trifling differences, which exist between the results obtained by Prof. Oltmanns and myself arise from his having made a more rigorous calculation from the whole of my observations, and his having employed the lunar tables of Burg, and of correspondent observations at Greenwich; while I used only the *Connaissance des Temps*, calculated from the tables of Masson.

The observations I had made on the dip of the needle, the intensity of the magnetic forces, and the small horary variations of the variation, will appear in a separate treatise, which will be added to my *Essay on Geological Pasigraphy*. This last work, which I began to compose in Mexico, in 1803, will be accompanied by profiles, indicating the stratification and relative age of the rocks, the types of which were observed by Mr. Leopold Von Buch and myself in the two continents, between the twelfth of southern and the seventy-first of northern latitude. Aided by the labors of this great geologist, who has examined

Europe from the North Cape in Lapland, and with whom I had the happiness of beginning my earliest studies at the school of Freiberg, I have been enabled to extend the plan of a work intended to throw some light on the construction of the Globe, and on the relative antiquity of it's formation.

After having distributed into separate works all that belongs to astronomy, botany, zoology, the political description of New Spain, and the history of the ancient civilization of certain nations of the New Continent, there still remained a great number of general results and local descriptions, which I might have collected into separate treatises. I had prepared several during my journey; on the races of men in South America; on the missions of the Oroonoko; on the obstacles to the progress of society in the torrid zone, from the climate, and the strength of vegetation: the character of the landscape in the Cordilleras of the Andes, compared with that of the Alps in Switzerland; the analogies between the rocks of the two hemispheres; on the physical constitution of the air in the equinoctial

regions; &c. I had left Europe with the firm intention of not writing what is usually called the historical narrative of a journey, but to publish the fruit of my inquiries in works merely descriptive; and I had arranged the facts, not in the order in which they successively presented themselves, but according to the relation they bore to each other. Amidst the overwhelming majesty of Nature, and the stupendous objects she present sat every step, the traveller is little disposed to record in his journal what relates only to himself, and the ordinary details of life.

I had composed a very brief itinerary during the course of my navigation on the rivers of South America, and in my long journies by land, in which I regularly described, and almost always on the spot, the excursions which I made toward the summit of a volcano, or any other mountain remarkable for it's height: but the composition of my journal was interrupted whenever I resided in a town, or when other occupations prevented me from continuing a work, which I considered as having only a secondary interest. When I employed



myself in the composition, I had no other motive than the preservation of some of those fugitive ideas, which present themselves to a naturalist, the whole of whose life is passed in the open air ; to make a temporary collection of such facts, as I had not then leisure to class ; and trace the first impressions, whether agreeable or painful, which I received from nature, or from man. Far from thinking at the time, that these pages, precipitately composed, would form the basis of an extensive work to be offered to the public, it appeared to me, that my journey, though it might furnish certain data useful to science, would present very few of those incidents, the recitals of which give the principal charm to an itinerary.

The difficulties which I have experienced since my return in the composition of a considerable number of treatises, in order to make known certain classes of phænomena, insensibly overcame my repugnance to write the narrative of my journey. In undertaking this task, I have been guided by the advice of a number of respectable

persons, who honour me with peculiar kindness. I even perceived, that so distinguished a preference is given to this sort of composition, that scientific men, after having presented in an isolated manner the account of their researches on the productions, the manners, and the political state of the countries through which they have passed, imagine that they have not fulfilled their engagements with the public, till they have written their itinerary.

An historical narrative embraces two very distinct objects ; the greater or less important events that have a connection with the purpose of the traveller, and the observations which he has made during his journey. The unity of composition also, which distinguishes good works from those on an ill constructed plan, can be strictly observed only when the traveller describes what has passed under his own eye ; and when his principal attention has been fixed less on scientific observations, than on the manners of a people, and the great phenomena of nature. Now, the most faithful picture of manners is that, which best

displays the relations of men toward each other. The character of savage or civilized nature is portrayed either in the obstacles which a traveller meets with, or in the sensations which he feels. It is the man himself that we continually desire to see in contact with the objects that surround him ; and his narration interests us the more, when a local tint is spread over the description of the country and it's inhabitants. Such is the source of the interest excited by the history of those first navigators, who, led on by intrepidity more than by science, struggled against the elements, while they sought a new world in unknown seas. Such is the irresistible charm which attaches us to the fate of that enterprising traveller \*, who, full of enthusiasm and energy, penetrated alone into the centre of Africa, in order to discover amidst barbarous nations the traces of ancient civilization.

In proportion as voyages have been made by persons more enlightened, and whose views have been directed towards researches into descriptive natural history,

geography or political economy, itineraries have partly lost that unity of composition, and that simplicity, which characterised those former ages. It is now become scarcely possible to connect so many different materials with the narration of events ; and that part which we may call dramatic gives way to dissertations merely descriptive. The great number of readers, who prefer an agreeable amusement to solid instruction, have not gained by the exchange ; and I am afraid, that the temptation will not be great to follow those travellers in their expeditions, who drag along with them a considerable apparatus of instruments and collections.

In order to give greater variety to my work, I have often interrupted the historical narrative by simple descriptions. I first describe the phenomena in the order in which they appeared ; and I afterward consider them in the whole of their individual relations. This mode has been successfully followed in the journey of Mr. de Saussure, whose most valuable work has contributed more than any other to the advancement of the sciences, and often,



amidst dry discussions on meteorology, contains many charming descriptions ; such as those of the modes of life of the inhabitants of the mountains, the dangers of hunting the chamois, and the sensations felt on the summit of the higher Alps.

These are details of ordinary life, which it might be useful to note in an itinerary, because they serve to regulate the conduct of those, who afterwards journey through the same countries. I have preserved a few, but have suppressed the greater part of those personal incidents, which offer no interesting situations, and which can be rendered amusing only by the perfection of style.

With respect to the country which has been the object of my investigations, I do not dissemble the great advantages, which those who travel to Greece, Egypt, the banks of the Euphrates, and the islands of the Pacific Ocean, enjoy over those who traverse America. In the ancient world, nations, and the distinctions of their civilization, formed the principal figures on the canvass ; in the new, man and his produc-

tions almost disappear amid the stupendous display of wild and gigantic nature. The human race here presents but a few remnants of indigenous hordes, slightly advanced in civilization; or that uniformity of manners and institutions, which has been transplanted by European colonists to foreign shores. What relates therefore to the history of our species, to the various forms of government, to the monuments of the arts, to those places which are full of great remembrances, affect us far more than the descriptions of those vast solitudes, which seem destined only for the display of vegetable life, and to form the domain of wild animals. The savages of America, who have been the object of so many systematic reveries, and on whom Mr. Volney has lately published some highly just and sagacious observations, inspire less interest, since celebrated navigators have made known to us the inhabitants of the islands of the South Sea, in whose character we find so striking a mixture of perversity and meekness. The state of half-civilization, in which those islanders are found, gives a

peculiar charm to the description of their manners. Here a king, followed by a numerous suite, comes and presents the fruits of his orchard ; there, the funereal festival imbrowns the shade of the lofty forest. Such pictures, no doubt, have more attraction than those, which portray the solemn gravity of the inhabitant of the banks of the Missouri or the Maranon.

If America occupies no important place in the history of mankind, and of the ancient revolutions which have agitated the human race, it offers an ample field to the labours of the naturalist. On no other part of the Globe is he called upon more powerfully by nature, to raise himself to general ideas on the cause of the phenomena, and their natural connection. I shall not speak of that luxuriance of vegetation, that eternal spring of organic life, those climates varying by stages as we climb the flanks of the Cordilleras, and those majestic rivers which a celebrated writer \* has described with so much grace-

\* Mr. Chateaubriand.

ful precision. The means which the new world affords for the study of geology and natural philosophy in general are long since acknowledged. Happy the traveller who is conscious, that he has availed himself of the advantages of his position, and that he has added some new facts to the mass of those which were already acquired !

It is almost useless to recapitulate what I have already observed in the preface to the equinoctial plants, that, connected by the most intimate ties of friendship with Mr. Bonpland, during the course of our travels and the years that have followed, we publish in common the whole of the works, which are the fruit of our labours. I have endeavoured to explain the facts, such as we observed them together ; but this narrative having been composed by myself, from notes written by me on the spot, whatever errors may be found in my recital must be attributed to myself alone.

The observations we made during the course of our journey have been distributed into six sections : the first comprehends



the historical narrative : the second zoology and comparative anatomy ; the third, the political essay on the kingdom of New Spain ; the fourth, astronomy ; the fifth, physics and geology ; and the sixth, the description of the new plants collected in both Americas. The editors have displayed a liberal zeal to render these works worthy of the public attention. I cannot pass over in silence the frontispiece to this itinerary. Mr. Gerard, with whom I have had the pleasure of being acquainted these fifteen years, has devoted to me some moments of his time, and I feel the value of this public testimony of his esteem and friendship.

I have carefully mentioned in this work the persons, who have had the kindness to communicate to me their observations ; and in this introduction I ought to express my gratitude to Messrs. Gay-Lussac, and Arago, my fellow members of the Institute, who have annexed their names to important labours, and who are endowed with that elevation of character, which is so congenial to an ardent love of the sciences. Living

with them on terms of the most intimate friendship, I have had the means of consulting them daily on objects of chemistry, natural history, and several branches of the mathematics. I have already mentioned in the collection of my astronomical observations what I owe to the friendship of Mr. Arago, who, after having terminated the measure of the meridian of Spain, has been exposed to so many dangers; and who unites the talents of an astronomer with those of a geometrician and a naturalist. At the period of my return I discussed particularly with Mr. Gay-Lussac the different phenomena of meteorology and physical geology, which I had amassed in my journey. For eight years past we have usually dwelt under the same roof in France, Germany, and Italy; we have witnessed together one of the great eruptions of Vesuvius; and have joined our labours on the chemical analysis of the atmosphere, and the variations of terrestrial magnetism. I have been enabled to avail myself of the profound and ingenious views of this chemist, in correcting my ideas re-

specting several objects, of which I treat in the narrative of my journey.

Since I left America, one of those great revolutions, which at certain periods agitate the human race, has burst forth in the Spanish colonies, and seems to prepare new destinies for a population of fourteen millions of inhabitants; spreading itself from the southern to the northern hemisphere, from the shores of Rio La Plata and Chili to the remotest part of Mexico. Deep resentments, excited by colonial legislation, and fostered by mistrustful policy, have stained with blood those countries, which had enjoyed during the last three ages what I will not call happiness, but uninterrupted peace. Already at Quito the most virtuous and enlightened citizens have perished victims of devotion to their country. While I am giving the description of regions, the remembrance of which is so dear to me, I meet at every step with places, which recall to my mind the loss of a friend.

When we reflect on the great political agitations of the new world, we observe,

that the Spanish Americans are by no means in so favorable a position as the inhabitants of the United States, prepared for independance by the long enjoyment of constitutional liberty. Internal dissensions are chiefly to be dreaded in regions, where civilization is but slightly rooted ; and where, from the influence of climate, the forests may soon regain their empire over cleared lands, if their culture be abandoned. It is also to be apprehended, that, during a long series of years, no foreign traveller will be enabled to traverse the whole of the countries, which I have visited. This circumstance may perhaps add to the interest of a work, that portrays the state of the greater part of the Spanish colonies at the beginning of the 19th century. I may even indulge the hope, under the influence of more soothing ideas, that this work will be thought worthy of attention, when the passions shall be hushed into peace ; and when, under the influence of a new social order, those countries shall have made a rapid progress towards public welfare. If then some pages of my book are snatched



from oblivion, the inhabitant of the banks of the Oroonoko will behold with extasy, that populous cities enriched by commerce, and fertile fields cultivated by the hands of freemen, adorn those very spots, where, at the time of my travels, I found only impenetrable forests, and inundated lands.



# TABLES.

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1 toise	=	6 feet 4.736 inches
1 foot (pié du roi)	=	12.789
1 metre	=	3 3.371

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Table of Degrees of the Centigrade Thermometer, from the point of boiling water to that of freezing mercury, reduced to Fahrenheit's scale.

Centigr.	Fahren.	Centigr.	Fahren.	Centigr.	Fahren.
100	212	78	172.4	56	132.8
99	210.2	77	170.6	55	131
98	208.4	76	168.8	54	129.2
97	206.6	75	167	53	127.4
96	204.8	74	165.2	52	125.6
95	203	73	163.4	51	123.8
94	201.2	72	161.6	50	122
93	199.4	71	159.8	49	120.2
92	197.6	70	158	48	118.4
91	195.8	69	156.2	47	116.6
90	194	68	154.4	46	114.8
89	192.2	67	152.6	45	113
88	190.4	66	150.8	44	111.2
87	188.6	65	149	43	109.4
86	186.8	64	147.2	42	107.6
85	185	63	145.4	41	105.8
84	183.2	62	143.6	40	104
83	181.4	61	141.8	39	102.2
82	179.6	60	140	38	100.4
81	177.8	59	138.2	37	98.6
80	176	58	136.4	36	96.8
79	174.2	57	134.6	35	95

Centigr.	Fahren.	Centigr.	Fahren.	Centigr.	Fahren.
34	93·2	9	48·2	16	3·2
33	91·4	8	46·4	17	1·4
32	89·6	7	44·6	18	—0·4
31	87·8	6	42·8	19	2·2
30	86	5	41	20	4
29	84·2	4	39·2	21	5·8
28	82·4	3	37·4	22	7·6
27	80·6	2	35·6	23	9·4
26	78·8	1	33·8	24	11·2
25	77	0	32	25	13
24	75·2	—1	30·2	26	14·8
23	73·4	2	28·4	27	16·6
22	71·6	3	26·6	28	18·4
21	69·8	4	24·8	29	20·2
20	68	5	23	30	22
19	66·2	6	21·2	31	23·8
18	64·4	7	19·4	32	25·6
17	62·6	8	17·6	33	27·4
16	60·8	9	15·8	34	29·2
15	59	10	14	35	31
14	57·2	11	12·2	36	32·8
13	55·4	12	10·4	37	34·6
12	53·6	13	8·6	38	36·4
11	51·8	14	6·8	39	38·2
10	50	15	5	40	40

JOURNEY  
TO THE  
EQUINOCTIAL REGIONS  
OF  
THE NEW CONTINENT.

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BOOK I.

CHAPTER I.

*Preparations. — Instruments. — Departure from Spain. — Landing at the Canary Islands.*

WHEN a government undertakes one of those maritime expeditions, which contributes to the knowledge of the globe, and the progress of natural philosophy, there is no obstacle to the accomplishment of it's purpose. The time of departure, and the direction of the voyage may be fixed, whenever the vessel is equipped, and astronomers and naturalists are appointed to traverse unknown seas. The islands and coasts, the productions of which these travellers are prepared to examine, are subject to the influence of no European policy. If it happen that the freedom of



the seas be interrupted by lengthened hostilities, passports are mutually granted by the belligerent powers, and partial enmities disappear before the advancement of general knowledge, which is the general cause of all nations. Far different is the situation of a private individual, who undertakes a journey at his own expense into the interior of a continent, over which Europe has extended it's system of colonization. The traveller in vain meditates the plan, which he judges the most convenient either for the object of his investigations, or the political state of the country he intends to examine; he collects in vain all his resources, which in distant regions may secure him for a long time an independant existence; his designs are often thwarted by unforeseen obstacles at the moment that he thinks of putting them into execution. Few individuals have had greater difficulties to struggle with than myself, before my departure for Spanish America; I should spare the recital, and begin this narrative by the expedition to the summit of the Peak of Teneriffe, had not the failure of my first projects had a decided influence on the direction I have given my travels since my return from the Orinoco. I shall, however, pass rapidly over those events which have no interest for science, but which I wish to present in their true light. The curiosity of the public being oftener fixed on the persons of travellers than on their works, what

relates to the first plans I had traced out, has been strangely disfigured\*.

From my earliest youth I had felt an ardent desire to travel into distant regions, which Europeans had seldom visited. This desire is the characteristic of a period of our existence, when life appears an unlimited horizon, and when we find an irresistible attraction in the impetuous agitations of the mind, and the image of positive danger. Educated in a country which has no direct communication with the colonies of either India, living amidst mountains, remote from the coasts, and celebrated for their numerous mines, I felt an increasing passion for the sea, and distant expeditions. The objects with which we are acquainted only by the animated narratives of travellers, have a particular charm; imagination wanders with delight over what is vague and undefined; and the pleasures of which we are deprived, seem possessed of a fascinating power

\* I here beg leave to observe, that I never had the slightest knowledge of a work in six volumes, published by Vollmer, at Hamburgh, under the strange title of "Voyage round the World, and in South America, by A. de Humboldt." This narrative, which appeared in my name, was compiled, it seems, from accounts given in the public papers, and from memoirs which I read to the first class of the Institute. The compiler, with a view of engaging the attention of the public, thought he might give to an expedition made to some parts of the New Continent, the more attractive title of Voyage round the World.

compared to which all we daily feel in the narrow circle of sedentary life appears insipid. The taste for herborisation, the study of geology, rapid excursions to Holland, England, and France, with the celebrated Mr. George Forster, who had the happiness to accompany Captain Cook in his second expedition round the globe, contributed to give a determined direction to the plan of travels which I had formed at eighteen years of age. No longer deluded by the agitation of a wandering life, I was anxious to contemplate nature in all its variety of wild, and stupendous scenery; and the hope of collecting some facts useful to the advancement of science, incessantly impelled my wishes towards the luxuriant regions spread under the torrid zone. As my personal situation then prevented me from executing the projects by which I was so powerfully influenced, I had leisure to prepare myself during six years, for the observations I purposed to make on the New Continent, to visit different parts of Europe, and explore the lofty chain of the Alps, the structure of which I might afterwards compare with that of the Andes, of Quito, and of Peru. As I employed successively instruments of different constructions, I fixed my choice on those which appeared to me the most exact, and the least subject to break in the carriage. I had an opportunity of repeating measurements which had been taken according to

the most rigorous methods ; and I learnt from experience, the extent of the errors to which I might be exposed.

I had traversed a part of Italy in 1795 ; but had not been able to visit the volcanic regions of Naples and Sicily ; and I regretted leaving Europe without having seen Vesuvius, Stromboli, and *Ætna*. I felt, that in order to form a proper judgment of a great number of geological phenomena, especially of the nature of the rocks of trap formation, it became necessary to have examined strictly the phenomena offered by burning volcanoes. I determined therefore to return to Italy in the month of November, 1797. I made a long stay at Vienna, where the fine collections of exotic plants, and the friendship of Messrs. de Jacquin, and of Mr. Joseph Van der Schott were highly useful to my preparatory studies. I travelled with Mr. Leopold de Buch, who has since published an excellent work on Lapland, through several cantons of Salzburgh and Styria, countries alike interesting to the landscape-painter and the geologist ; but at the moment I was passing the Tyrolian Alps, the war which raged in Italy obliged me to abandon the project of going to Naples.

A short time before, a person who was passionately fond of the fine arts, and who had visited the coasts of Greece and Illyria to inspect their monuments, made me a proposal to accompany



him in an expedition to upper Egypt. This expedition was to last only eight months: provided with astronomical instruments and able draughtsmen, we were to ascend the Nile as far as Assouan, after minutely examining the positions of the Saïd, between Tentyris and the cataracts. Though my views had not hitherto been fixed on any region beyond the tropics, I could not resist the temptation of visiting countries so celebrated in the annals of human civilization. I therefore accepted this proposition, but with the express condition, that on our return to Alexandria, I should be at liberty to continue my journey through Syria and Palestine. I directed henceforth my studies in conformity to this new project, which I afterward found useful, when I examined the relations between the barbarous monuments of Mexico, and those belonging to the nations of the old world. I thought myself on the point of embarking for Egypt, when political events forced me to abandon a plan, which promised me so much satisfaction. The situation of the East was such, that no individual could hope to pursue operations, which even in the most peaceful times often expose the traveller to the suspicion of its governments.

An expedition of discoveries in the Southern Ocean, under the direction of Captain Baudin, was then preparing in France. The first plan was great, bold, and worthy of being executed by a



more enlightened commander. The purpose of this expedition was to visit the Spanish possessions of South America, from the mouth of the river Plata, to the kingdom of Quito and the isthmus of Panama. After traversing the Archipelago of the great Ocean, and exploring the coasts of New Holland, from Diemen's Land to that of Nuyts, both vessels were to stop at Madagascar, and return by the Cape of Good Hope. I was at Paris when the preparations for this voyage were begun. I had but little confidence in the personal character of Captain Baudin, who had given cause of discontent to the Court of Vienna, when he was commissioned to conduct to Brazil one of my friends, the young botanist, Mr. Van der Schott; but as I could not hope, with my own resources, to make a voyage of such extent, and view so fine a portion of the globe, I determined to take the chances of this expedition. I obtained permission to embark with the instruments I had collected, in one of the vessels destined for the South Sea, and I reserved to myself the liberty of leaving Captain Baudin, whenever I thought proper. Mr. Michaux, who had already visited Persia, and a part of North America, and Mr. Bonpland, with whom I formed a friendship that still unites us, were appointed to accompany this expedition as naturalists.

I had flattered myself during several months with the idea of sharing in labors directed to so

great and honourable an object, when the war which broke out in Germany and Italy determined the French government to withdraw the funds granted for their voyage of discovery, and adjourn it to an indefinite period. Cruelly deceived in my hopes, seeing the plans which I had been forming during many years of my life, overthrown in a single day, I sought at any risk the speediest means of quitting Europe, and engaging in some enterprize, which might console me for my disappointment.

I became acquainted with a Swedish Consul Mr. Skioldebrand, who, appointed by his Court to carry presents to the Dey of Algiers, passed through Paris, in order to embark at Marseilles. This estimable man had resided a long time on the coasts of Africa, and being highly respected by the government of Algiers, he could easily procure me permission to visit that part of the chain of the Atlas, which had not been the object of the important researches of Mr. Desfontaines. He dispatched every year a vessel for Tunis, where the pilgrims embarked for Mecca, and he promised to convey me by the same occasion to Egypt. I eagerly seized so favorable an opportunity, and thought myself on the point of executing a plan, which I long formed previous to my arrival in France. No mineralogist had yet examined that lofty chain of mountains, which in the empire of Morocco rises to

the limit of the perpetual snows. I flattered myself, that, after executing some useful operations in the Alpine regions of Barbary, I should receive in Egypt from those illustrious men who had for some months formed the Institute of Cairo, the same kind attentions with which I had been honored during my abode in Paris. I hastily completed my collection of instruments, and purchased works which related to the countries I was going to visit. I separated myself from a brother, who by his advice and example had hitherto exercised a great influence on the direction of my thoughts. He approved the motives which determined me to quit Europe : a secret voice assured us that we should meet again ; and that hope, which has not proved delusive, softened the pain of a long separation. I left Paris with the intention of embarking for Algiers and Egypt ; but in consequence of one of those vicissitudes which sway the affairs of this life, I returned to my brother, from the river of Amazons and Peru, without having touched the continent of Africa.

The Swedish frigate, which was to convey Mr. Skioldebrand to Algiers, was expected at Marseilles toward the end of October. Mr. Bonpland and myself repaired thither, with so much the more celerity, as during our journey we were tormented with the fear of being too late, and missing our passage. We did not at that time foresee the new impediments that awaited us.

Mr. Skioldebrand was no less impatient than ourselves to reach his place of destination. Several times a day we climbed the mountain of Notre Dame de la Garde, which commands an extensive view of the Mediterranean. Every sail which we descried in the horizon excited in us the most powerful emotion: but after two months of anxiety, and vain expectation, we learnt by the public papers, that the Swedish frigate which was to convey us, had suffered greatly in a storm on the coasts of Portugal, and had been forced to enter the port of Cadiz, to refit. This news was confirmed by private letters, assuring us that the *Jaramas*, which was the name of the frigate, would not reach Marseilles before the Spring.

We had not the courage to prolong our stay in Provence to this period. The country, and especially the climate, were delightful, but the aspect of the sea reminded us of the failure of our projects. In an excursion we made to Hyeres, and Toulon, we found in this last port, the frigate *La Boudeuse*, which had been commanded by Mr. de Bougainville in his voyage round the world, fitting out for Corsica. This illustrious navigator had honored me with particular kindness during my stay at Paris, when I was preparing to accompany the expedition of Captain Baudin. I cannot describe the impression made upon my mind by the sight of the vessel which had carried Commerson to the islands of



the Southern Sea. There are dispositions of the soul, in which a painful emotion blends itself with all our feelings.

We still persisted in our intention of visiting the African coasts, and were nearly becoming the victims of this perseverance. A small vessel of Ragusa, on the point of setting sail for Tunis, was at this period in the port of Marseilles ; we thought the opportunity favorable to reach Egypt and Syria, and we agreed with the captain for our passage. The vessel was to sail the following day, but a circumstance, trivial in itself, happily prevented our departure. The animals that were to serve us for food, during our passage, were kept in the great cabin. We desired that some changes should be made, which were indispensable for the safety of our instruments ; and during this interval we learnt at Marseilles, that the government of Tunis persecuted the French residing in Barbary, and that every person coming from a French port was thrown into a dungeon. Having escaped this imminent danger, we were compelled to suspend the execution of our projects, and resolved to pass the winter in Spain, in hopes of embarking the next spring, either at Carthagera, or at Cadiz, if the political situation of the East permitted.

We crossed Catalonia, and the kingdom of Valencia, in our way to Madrid. We visited the ruins of Tarragona, and those of the antient Sa-



guntum; and from Barcelona made an excursion to Montserrat\*, the lofty peaks of which are inhabited by hermits, and where the contrast between luxuriant vegetation, and masses of naked and arid rocks, forms a landscape of a peculiar character. I employed myself in ascertaining by astronomical methods the position of several important points for the geography of Spain†, and determined by means of the barometer the height of the central plain‡; and I made several obser-

\* Mr. William de Humboldt, who travelled through the whole of Spain, a short time after my departure from Europe, has given a description of this place in the *Geographical Ephemerides of Weimar* for 1803.

† *Astronomical Observations*, Vol. 1. Introduction, page 35 to 37, and lib. 1, page 3 to 33. At this period the latitude of Valencia was still several minutes uncertain. I found the cathedral (which Tofino places in  $39^{\circ} 26' 30''$ ) to be  $39^{\circ} 28' 42''$ , latitude, and  $0^{\text{h}} 11' 0.3''$  longitude. Four years later, Baron de la Puebla, and Mr. Mechain, fixed this point by zenith distances taken with a repeating circle, and by the occultations of stars, to be  $39^{\circ} 28' 37.6''$  latitude, and  $0^{\text{h}} 11' 0.6''$  longitude. At Murviedro (the ancient Saguntum) I determined the position of the ruins of the temple of Diana, near the convent of the Trinitarians. These ruins are in  $39^{\circ} 40' 26''$  lat. and  $0^{\text{h}} 10' 34''$  longitude.

‡ See my notice on the configuration of the territory of Spain, in the itinerary of Mr. de la Borde, Vol. 1, p. 147. According to Mr. Bauza, the medium height of the barometer at Madrid is 26 inches 2.4 lines, whence it results, according to the method of Mr. Laplace, and the new coefficient of Mr. Ramond, that the capital of Spain is 309 toises

vations on the inclination of the needle, and on the intensity of the magnetic forces. The results of these observations have been separately published, and I shall enter into no detail on the natural history of a country, in which I resided only six months, and which has recently been examined by so many well-informed travellers.

On my arrival at Madrid I had reason to congratulate myself on the resolution I had taken to visit the peninsula. Baron de Forell, minister from the court of Saxony, treated me with a degree of kindness, of which I soon felt the value. He was well versed in mineralogy, and had the purest zeal for every undertaking, that promoted the progress of knowledge. He observed to me, that under the administration of an enlightened minister, Don Mariano Luis de Urquijo, I might hope to obtain permission to visit, at my own expense, the interior of Spanish America. After

(603 metres) above the level of the ocean. This result is nearly the same as that found by Don Jorge Juan, and published by Mr. Lalande, by which the height of Madrid above the level of Paris is 294 toises (Mem. of the Acad. 1776, page 148). The highest mountain of the peninsula is not, as has been hitherto thought, Mount Perdu, but the Mulahacen, which forms part of the Sierra Nevada of Grenada. This peak, according to the geodesical levelling of Don Clemente Roxas, is 1824 toises of absolute height, whilst Mount Perdu, in the Pyrenees, is only 1763 toises. Near the Mulahacen is situate the Pico de Veleta, which is 1781 toises.

the disappointments I had undergone, I did not hesitate a moment to adopt this idea.

I was presented to the court of Aranjuez in March, 1799. The king received me graciously. I explained to him the motives, which led me to undertake a voyage to the new continent, and the Philippine islands, and I presented a memoir on this subject to the secretary of state. Mr. d'Urquijo supported my demand, and overcame every obstacle. The conduct of this minister was so much the more generous, as I had no personal connection with him, and the zeal which he constantly showed for the execution of my projects had no other motive than his love for the sciences. I feel that it is no less a duty than a pleasure, to record in this work the services which he rendered me.

I obtained two passports, one from the first secretary of state, the other from the council of the Indies. Never had so extensive a permission been granted to any traveller, and never had any foreigner been honoured with more confidence on the part of the Spanish government. To dissipate every doubt, which the viceroys or captains general, representing the royal authority in America, might entertain with respect to the nature of my labors, the passport of the *primera secretaria de estado* stated, that I was authorized to make free use of my instruments of physic and geodesy, that I might make astronomical

observations through the whole of the Spanish dominions, measure the height of mountains, examine the productions of the soil, and execute all operations which I should judge useful for the progress of the sciences\*. These orders of the court were strictly followed, even after the events which obliged Mr. d'Urquijo to quit the ministry. I endeavoured on my part to justify by my conduct these marks of unceasing attention. During my abode in America, I presented the governors of the Provinces with a duplicate of the materials which I had collected, and which might interest the mother country by throwing some light on the geography and the statistics of the colonies. Agreeably to the offer I had made before my departure, I addressed several geological collections to the cabinet of natural history of Madrid. The purpose of our journey

\* Ordena S. M. a los Capitanes generales, comandantes, gobernadores, yntendentes, corregidores y demas justicias no impidan por ningun motivo la conduccion de los instrumentos de fisica, qaimica, astronomia y matematicas, ni el hacer en todas las posesiones ultramarinas las observaciones y experimentos que juzgúe utiles, como tampoco el coleccionar libremente plantas, animales, semillas y minerales, medir la altura de los montes, examinar la naturaleza de estos y hacer observaciones astronomicas y descubrimientos utiles para el progreso de las ciencias: pues por el contrario quiere el Rey que todas las personas a quienes corresponda, den al B. de Humboldt todo el favor, auxilio y proteccion que necesite. (De Aranjuez, 7 de mayo 1799.)



being merely scientific, we succeeded in conciliating the friendship of the natives, and that of the Europeans entrusted with the administration of these vast countries. During the five years that we travelled throughout the new continent, we did not perceive the slightest mark of mistrust; and we remember with pleasure, that amidst the most painful privations, and whilst we were struggling against the obstacles which arose from the savage state of those regions, we never had to complain of the injustice of men.

Many considerations might have induced us to prolong our abode in Spain. The Abbe Cavanilles, no less remarkable for the variety of his attainments than his acute intelligence, Mr. Nee, who, together with Mr. Hænke, had, as botanist, made part of the expedition of Malaspina, and who had formed one of the greatest herbals that was ever seen in Europe; Don Casimir Ortega, the Abbe Pourret, and the learned authors of the Flora of Peru, Messrs. Ruiz and Pavon, opened to us without restriction their rich collections. We examined part of the plants of Mexico discovered by Messrs. Sesse, Mocino and Cervantes, whose drawings had been sent to the Museum of Natural History of Madrid. This great establishment, the direction of which was confided to Mr. Clavijo, author of an elegant translation of the works of Buffon, offered us, it is true, no geological *suite* of the Cordilleras, but Mr. Proust,



so well known by the great accuracy of his chemical labours, and a distinguished mineralogist, Mr. Hergen, gave us curious details on several mineral substances of America. It would have been useful to us, to have employed a longer time in studying the productions of the countries, which were to be the objects of our researches, but our impatience to take advantage of the permission given us by the court was too great, to suffer us to delay our departure. For a year past, I had experienced so many disappointments, that I could scarcely persuade myself, that my most ardent wishes would be at length fulfilled.

We left Madrid about the middle of May, crossed a part of Old Castile, the kingdoms of Leon and Gallicia, and reached Corunna, whence we were to embark for the Island of Cuba. The winter having been long and tempestuous, we enjoyed during the journey that mild temperature of the spring, which in so southern a latitude is commonly that of March and April. The snow still covered the lofty granitic tops of the Guadarama ; but in the deep vallies of Gallicia, which resemble the most picturesque spots of Switzerland and the Tyrol, cistuses loaded with flowers and arborescent heaths clothed every rock. We quitted without regret the elevated plain of the two Castiles, which is every where deprived of vegetation, and where the severity of the winter's cold is followed by the overwhelming heat

of summer. From the few observations I personally made, the interior of Spain forms a vast plain, which, elevated three hundred toises (five hundred and eighty-four metres) above the level of the ocean, is covered with secondary formations, grit stone, gypsum, salgem, and the calcareous stone of Jura. The climate of the Castiles is much colder than that of Toulon and Genoa; for it's mean temperature scarcely rises to 15° of the centigrade thermometer\*.

We are astonished to find, that in the latitude of Calabria, Thessaly, and Asia Minor, the orange-trees do not flourish in the open air†. The central elevated plain is encircled by a low and narrow zone, where the chamærops, the date-tree, the sugar cane, the banana, and a number of plants common to Spain and the north of Africa, vegetate on several spots, without suffering from the rigors of winter. From the 36th to the 40th degrees of latitude, the medium temperature of the year is from 17 to

\* Whenever in the course of this work, the contrary is not expressly indicated, the variations of the temperature are noted after the centigrade scale of the thermometer with mercury; but to avoid the errors which may arise from the reductions of the different scales, and the frequent suppression of decimal fractions, I have printed the partial observations, such as the instrument I made use of gave me. On this point I have followed the plan adopted by the illustrious author of the *Basis of the Metrical System*, M. Delambre.

† For the note see the following page.

+ As in the course of this historical narrative, the influence of the medium temperature in the unfolding of vegetation and the productions of agriculture is often mentioned, it will be proper to give in this place the following data, founded on exact observations, and adapted to serve as terms of comparison. I have added an asterisk to the names of cities, the climate of which is singularly modified, either by their elevation above the level of the ocean, or by the circumstances independent of the latitude.

	Lat.	63° 50'	Mean Temp.	0-7°	
Umeö - - - - -	-	-	-	3-8	(Næzen and Buch).
Petersburgh - - - - -	-	59 56	-	5-5	(Euler). Very eastern position.
Upsal - - - - -	-	59 51	-	5-7	(Buch).
Stockholm - - - - -	-	59 20	-	7-6	(Wargentin).
Copenhagen - - - - -	-	55 41	-	8-1	(Bugge).
Berlin - - - - -	-	52 31	-	10-7	(Bouvard), average of 7 years.
Paris - - - - -	-	48 50	-	10-1	Height, 396 metres.
Geneva* - - - - -	-	46 12	-	14-3	Saint Jacques.
Marseilles - - - - -	-	43 17	-	17-5	Mountains to the north.
Toulon* - - - - -	-	43 3	-	15-7	(William de Humboldt).
Rome - - - - -	-	41 53	-	18-0	
Naples - - - - -	-	40 50	-	15-0	Height, 603 metres.
Madrid* - - - - -	-	40 25	-	17-0	Height, 2277 metres.
Mexico* - - - - -	-	19 25	-	25-4	Dry sandy coast.
Vera Cruz* - - - - -	-	19 11	-	27-0	
Equator at the level of the Ocean - - - - -	-	0 0	-	15-0	Height, 2908 metres.
Quito - - - - -	-	0 14	-		

This table differs slightly from that I gave in the introduction to Thomson's Chemistry, Vol. 1, p. 99, (French translation) and which was not formed from observations equally exact.

20 degrees ; and by a concurrence of circumstances, which it would be too long to explain, this happy region is become the principal seat of industry and intellectual improvement.

Ascending from the shores of the Mediterranean into the kingdom of Valencia, towards the lofty plains of La Mancha and the Castiles, we seem to recognize far inland, from the lengthened declivities, the ancient coast of the Peninsula. This curious phenomenon recalls the traditions of the Samothracians, and other historical testimonies, according to which it is supposed, that the eruption of the waters through the Dardanelles, augmenting the basin of the Mediterranean, rent and overflowed the southern part of Europe. If we admit that these traditions owe their origin, not to mere geological reveries, but to the remembrance of some ancient catastrophe, we see the central elevated plain of Spain resisting the efforts of these great inundations, till the draining of the waters, by the straights formed between the pillars of Hercules, brought the Mediterranean progressively to it's level, while Lower Egypt emerged above it's surface on the one side, and the fertile plains of Tarragon, Valencia, and Murcia, on the other. Every thing that relates to the formation of this sea\*,

\* Diodor. Sicul. edit. Wesseling. Amstelodam., 1746, Lib. iv, c. 19, p. 336; Lib. v. c. 47, p. 369. Dionys.



which has had so powerful an influence on the first civilization of mankind, is highly interesting. We might suppose, that Spain, forming a promontory amidst the waves, was indebted for it's preservation to the height of it's land; but in order to give weight to these systematic ideas, we must clear up the doubts that have arisen respecting the rupture of so many transverse dikes; we must discuss the probability of the

Halicarn. ed. Oxon. 1704, Lib. i, c. 61, p. 49. Aristot. Opp. omn. ed. Casaub. Lugdun. 1590. Meteorolog. Lib. i, c. 14, t. 1, p. 336. H. Strabo, Geogr. ed. Thomas Falconer. Oxon. 1807, t. 1, p. 76 et 83. (Tournefort, Voyage au Levant, p. 124. Pallas, Voyage en Russie, t. v, p. 195. Choiseul-Gouffier, Voyage pittoresque, t. ii, p. 116. Dureau de la Malle, Géographie physique de la Mer Noire, p. 157, 196, et 341. Olivier, Voyage en Perse, t. iii, p. 130. Meiners über die Verschiedenheiten der Menschennaturen, p. 118.) Some of the ancient geographers, such as Straton, Eratosthenes, and Strabo, believed, that the Mediterranean, swelled by the waters of the Euxine, the Palus Meotis, the Caspian Sea, and the lake Aral, had broken the pillars of Hercules; others, such as Pomponius Mela, admitted, that the irruption was made by the waters of the ocean. In the first of these hypotheses, the height of the land between the Black Sea and the Baltic; and between the ports of Certe and Bourdeaux, determines the limit, which the accumulation of the waters may have reached before the junction of the Black Sea, the Mediterranean, and the Ocean, as well to the north of the Dardanelles, as to the east of this strip of land, which formerly joined Europe to Mauritania, and of which in the time of Strabo certain vestiges remained in the Islands of Juno and the Moon.



Mediterranean having been formerly divided into several separate basins, of which Sicily and the Isle of Crete appear to mark the ancient limits. We will not here risk the solution of these problems, but will satisfy ourselves in fixing the attention on the striking contrast in the configuration of the land in the eastern and western extremities of Europe. Between the Baltic and the Black Sea, the ground is at present scarcely fifty toises above the level of the ocean, while the plain of La Mancha, if placed between the sources of the Niemen and the Borysthenes, would figure as a group of mountains of considerable height. If the causes, which may have changed the surface of our planet, be an interesting speculation, investigations of the phenomena, such as they offer themselves to the measures and observations of the naturalist, lead to far greater certainty.

From Astorga to Corunna, especially from Lugo, the mountains rise gradually. The secondary formations gently disappear, and are succeeded by the transition rocks, which indicate the proximity of primitive strata. We found considerable mountains composed of that ancient gray stone, which the mineralogists of the school of Fribourg name *grauwakke*, and *grauwakkenschiefer*. I do not know whether this formation, which is not frequent in the south of Europe, has hitherto been discovered in other

parts of Spain. Angular fragments of lydian stone, scattered along the vallies, seemed to indicate, that the transition schist is the basis of the strata of grauwakke. Near Corunna even granitic ridges stretch as far as Cape Ortegal. These granites, which seem formerly to have been contiguous to those of Britanny and Cornwall, are perhaps the wrecks of a chain of mountains destroyed and sunk in the waves. Large and beautiful crystals of feldspath characterize this rock; the common tin ore is sometimes discovered there, the working of which is a laborious and unprofitable operation for the inhabitants of Gallicia.

When we reached Corunna, we found the port blockaded by an English man of war and two frigates, which were stationed to intercept the communication between the mother-country and the American colonies; since it was from Corunna, and not from Cadiz, that a packet boat (*correo maritimo*) sailed every month for the Havannah, and another every two months for Buenos Ayres, or the mouth of the river Plata. I shall in the course of my work give an exact statement of the posts on the new continent; and shall here only observe, that since the administration of Count Florida Blanca, the service of the land post office has been so well organized, that an inhabitant of Paraguay, or of the province of

Jaen de Bracamoros\*, may carry on a regular correspondence with New Mexico, or the coasts of California, at a distance equal to that from Paris to Siam, or from Vienna to the Cape of Good Hope. In the same manner, a letter confided to the post in a small town of Aragon arrives at Chili, or in the missions of the Oroonoko, provided the name of the corregimento, or district that comprises the Indian village to which the letter is addressed, be distinctly marked. It is pleasing to recall to mind institutions, which may be considered as among the greatest benefits of modern civilization. The establishment of maritime and inland posts has placed the colonies in more intimate intercourse with each other, and with the mother-country. The circulation of ideas is become more expeditious; the complaints of the natives reach Europe with more facility, and the supreme authority has sometimes succeeded in repressing vexations, which, from the distance of the place, would have remained for ever unknown.

The first secretary of state had recommended us very particularly to the brigadier Don Raphael Clavijo, who had lately been named director-general of the maritime posts. This officer, distinguished for his talent in ship-building, was employed in forming new dock-yards at Corun-

\* On the banks of the river of Amazons.

na. He neglected nothing to render our abode at this port agreeable, and advised us to embark on-board the sloop Pizarro\*, which was to sail in company with the Alcudia, the packet-boat of the month of May, which, on account of the blockade, had been detained three weeks in the port. The Pizarro was not esteemed a swift sailer: but she had happily escaped the English vessels in her long voyage from the river Plata to Corunna. Mr. Clavijo ordered the necessary arrangements to be made on board the sloop for placing our instruments, and facilitating the means of making chemical experiments on the air, during our passage. The captain of the Pizarro received orders to stop at Teneriff, as long as we should judge necessary, to visit the port of Orotava, and ascend the peak.

We had yet ten days to wait before we embarked, which seemed to us a long delay. During this interval, we employed ourselves in preparing the plants we had collected in the beautiful vallies of Gallicia, which no naturalist had yet visited: we examined the fuci and the moluscæ which the north west winds had cast with great profusion at the foot of the steep rock, on which the light-house of the Tower of Hercules is built. This edifice, called also the Iron

\* According to the Spanish nomenclature, the Pizarro was a light frigate (*fragata lijera*).



Tower, was repaired in 1788. It is ninety-two feet high, its walls are four feet and a half thick, and its construction clearly proves, that it was built by the Romans. An inscription discovered near its foundations, a copy of which Mr. Laborde obligingly gave me, informs us, that this pharos was constructed by Caius Sevius Lupus, architect of the city of Aqua Flavia (Chaves), and that it was dedicated to Mars. Why is the Iron Tower called in the country by the name of Hercules? Was it built by the Romans on the ruins of a Greek, or Phœnician edifice? Strabo, indeed, affirms, that Gallicia, the country of the Callæci, had been peopled by Greek colonies. According to an extract from the geography of Spain, by Asclepiades the Myrlæan, an ancient tradition stated, that the companions of Hercules had settled in these countries\*.

I made the necessary observations to assure myself of the rate of going of Lewis Berthoud's time-keeper, and I had the satisfaction to find, that it had not changed its diurnal retardation, notwithstanding the shocks it had met with in our journey from Madrid to Corunna. This circumstance was the more important, as much

\* Strabo, ed. Cassaub. Lutet. Par. 1620, Lib. iii, p. 157. The Phœnicians and Greeks visited the coasts of Gallieia (Gallæcia) to trade for tin, which they drew from this country as well as from the Cassiterides. *Strabo*, Lib. iii, p. 147. *Plin.* Lib. xxxiv, c. 16.



uncertainty existed respecting the true longitude of Ferrol, the centre of which town is  $10^{\circ} 20''$  east of the Tower of Hercules at Corunna. An occultation of Aldebaran, and a long series of eclipses of Jupiter's satellites, observed by Admiral Mazarredo, and calculated by Mechain, seemed to prove that, in the maritime atlas of Tofino, which is in other respects so accurate in the indication of partial distances, the determinate positions of Corunna and Ferrol were inexact by two or three leagues. My time-keeper confirmed these doubts respecting the operations of Tofino. I found\* the observatory of the Admiralty at Ferrol  $0^{\text{h}} 42' 21''$  west of Paris. The mean of all the observations made by the Spanish astronomers, and lately published by Mr. Espinosa, gives  $0^{\text{h}} 42' 2.5''$ . I have already observed, that several expeditions having set sail from this last port, the false position, which has been laid down, has had a disadvantageous influence on the longitudes of several towns of America, determined not by absolute observa-

\* *Observat. Astron. Introd.* p. xxxvi, t. i, p. 24 et 33. Espinosa, *Memorias sobre las observaciones astron. hechas por los navegantes espanoles*, 1809, t. i, p. 23. If we suppose, that my chronometer did not augment it's diurnal retardation during the passage from Madrid to Corunna, which would be contrary to direct experiments made at Marseilles, the longitude of Ferrol will still be  $23''$  of time more than that at which it is fixed by Mr. Tofino.

tions, but only by the difference of time. Although [time-keepers extend the limits of our geographical knowledge, they often contribute to propagate the mistake in the longitude of the point of departure, because they render the position of the coast in the most distant regions dependent on this single point.

The ports of Ferrol and Corunna communicate with the same bay, so that a vessel driven by bad weather towards the coast may anchor in either, according to the wind. This advantage is invaluable, where the sea is almost always tempestuous, as between the Capes Ortegal and Finisterre, which are the promontories *Trileucum* and *Artabrum* \* of the ancient geography. A narrow passage, flanked by perpendicular rocks of granite, leads to the extensive basin of Ferrol. No port in Europe has so extraordinary an anchorage, from its very inland position. The narrow and tortuous passage, by which vessels enter this port, has been opened, either by the irruption of the waves, or by the reiterated shocks of very violent earthquakes. In the New World, on the coasts of New Andalusia, the Laguna del Obispo, (Bishop's Lake) is formed exactly like the port of Ferrol. The most curious geological phenomena are often repeated at immense distances on the surface of conti-

\* Ptolemy cites the port of the Artabri: *Geogr. Lib. ii. cap. 6.* (*Bertii Theatr. geograph. vet. Amstel., 1613, p. 34.*)

nents ; and the naturalists, who have examined different parts of the globe, are struck with the extreme resemblance observed in the rents on coasts, in the sinuosities of the vallies, in the aspect of the mountains, and in their distribution by groups. The accidental concurrence of the same causes must have every where produced the same effects ; and amidst the variety of nature, an analogy of structure and form is observed in the arrangement of brute matter, as well as in the internal organization of plants and of animals.

Crossing from Corunna to Ferrol, in shallow water, near the White Signal, in the bay, which according to d'Anville is the Portus Magnus of the Ancients, we made several experiments by means of a valved thermometrical sounding lead, on the temperature of the ocean, and on the decrement of caloric in the successive strata of water. The thermometer on the bank, and near the surface, was from  $12.5^{\circ}$  to  $13.3^{\circ}$  centigrades, while in deep water it constantly marked  $15^{\circ}$  or  $15.3^{\circ}$ , the air being at  $12.8^{\circ}$ . The celebrated Franklin, and Mr. Jonathan Williams, author of the work which appeared at Philadelphia under the title of Thermometrical Navigation, were the first to invite the attention of naturalists to the phenomena of the temperature of the ocean over shoals, and in that zone of tepid and flowing waters, which runs from the Gulf of Mexico

to the Banks of Newfoundland, and the northern coasts of Europe. The observation, that the proximity of a sand-bank is indicated by a rapid descent of the temperature of the sea at it's surface, is not only interesting to the naturalist, but may become also very important for the safety of navigators. The use of the thermometer ought certainly not to lead us to neglect the use of the lead ; but the experiments, which I shall mention in the course of this narrative, sufficiently prove, that variations of temperature, sensible to the most imperfect instruments, indicate danger long before the vessel reaches the shoals. In such cases, the frigidity of the water may engage the pilot to heave the lead in places, where he thought himself in the most perfect safety. We shall examine in another place the natural causes of these complicated phenomena ; and shall only here observe, that the waters which cover the shoals owe in a great measure the diminution of their temperature to their mixture with the lower strata of water, which rise towards the surface on the edge of the banks.

A heavy sea from the North-west hindered us from continuing our experiments on the temperature of the ocean in the bay of Ferrol. The great height of the waves was the effect of an impetuous wind at sea, and forced the English vessels to retire from the coast. Desirous to avail ourselves of this opportunity of sailing, we



instantly embarked our instruments, books, and baggage; but the west wind, which blew still more impetuously, did not permit us to weigh anchor, and during this delay we wrote to our friends in France and Germany. The moment of leaving Europe for the first time is attended with a solemn feeling. We in vain summon to our minds the frequency of the communication between the two worlds; we in vain reflect on the great facility, with which, from the improved state of navigation, we traverse the Atlantic, which compared to the great ocean is but a larger arm of the sea; the sentiment we feel when we first undertake so distant a voyage is not the less accompanied by a deep emotion, unlike any other impression we have hitherto felt. Separated from the objects of our dearest affections, entering in some sort on a new state of existence, we are forced to turn back on the family of our thoughts, and we find them in a situation which they have never known before. Among the letters which I wrote at the time of our embarking, one had a considerable influence on the direction of our travels, and on our succeeding operations. When I left Paris with the intention of visiting the coasts of Spain, the expedition for discoveries in the Southern Ocean seemed to be adjourned for several years. I had agreed with Captain Baudin, that if, contrary to his expectation, his voyage took place at an ear-



lier period, and the news should reach me in time, I would endeavour to return from Algiers to a port in France, or Spain, to join the expedition. I renewed this promise on leaving Europe, and wrote to Mr. Baudin, that if the government persisted in sending him by Cape Horn, I would endeavour to meet him, either at Monte Video, Chili, or Lima, or wherever he should touch in the Spanish Colonies. In consequence of this engagement, I changed the plan of my journey, on reading in the American papers, in 1801, that the French expedition had sailed from the port of Havre, to make the tour of the globe from east to west. I hired a small vessel from Batabano, in the Island of Cuba, to Portobello, and thence crossed the isthmus to the coasts of the southern ocean ; this mistake of a journalist led Mr. Bonpland and myself to travel eight hundred leagues through a country we had no intention to visit. It was only at Quito, that a letter from Mr. Delambre, perpetual secretary of the first class of the institute, informed us that Captain Baudin went by the Cape of Good Hope, without touching on the eastern or western coasts of America.

I cannot recall without regret an expedition, which is connected with several events of my life, and the history of which has lately been sketched by a \* man of science, no less distin-

\* Mr. Perron, lost to the sciences at thirty-five years of age, after a long and painful illness. See an interesting me-

guished for the number of his discoveries, than by the noble courage which he displayed in circumstances of extreme difficulty and danger.

When I went into Spain I could not carry with me the complete collection of my physical, geodesical, and astronomical instruments. I had left the duplicates at Marseilles, with the intention of ordering them to be sent to Tunis or Algiers, when I should find an opportunity of passing over to the coasts of Barbary. In peaceable times travellers ought by no means to carry with them the complete collection of their instruments: they should on the contrary cause them to be sent successively, in order to replace such as suffer most by use and carriage. This precaution is particularly necessary, when they are obliged to determine a great number of points by means merely chronometrical. But in times of maritime warfare, it is highly prudent never to lose sight either of instruments, manuscripts, or collections. Sad experience, as I have observed in the introduction to this work, has confirmed the justness of this observation. Our abode at Madrid and Corunna had been too short, to transport from Marseilles the meteorological apparatus I had left.

It was in vain that I requested it's being sent

moir on the life of this traveller, by Mr. Deleuze, in his *Annales du Museum*, t. 17.

to the Havannah, after our return from the Oroonoko : neither the apparatus nor the achromatic telescopes, nor the timekeeper by Arnold, which I had sent for to London, reached America. The following is the list of the instruments I had collected for my journey from the year 1797, and which, excepting a small number easy to replace, served me till 1804.

LIST OF THE PHYSICAL AND ASTRONOMICAL INSTRUMENTS.

- A *timekeeper by Lewis Berthoud, No. 27.* This timekeeper had belonged to the celebrated Borda. I have published the detail of it's rate of going, in the introduction to my collection of astronomical observations ;
- A *demi-chronometer by Seyffert*, serving for ascertaining the longitude at short distances ;
- A *three-foot achromatic telescope by Dollond*, intended for the observation of Jupiter's satellites ;
- A *telescope by Caroché*, of less dimensions, with an apparatus to fix the instrument to the trunk of a tree, in forests ;
- A *lunette d'épreuve*, with a micrometer engraved on glass, by Mr. Köhler, astronomer at Dresden. This apparatus, placed on the plane of the artificial horizon, serves to level bases, to measure the progress of an eclipse of the sun or the moon, and determine the value of very

small angles under which very remote mountains appear ;

A *sextant by Ramsden*, of ten inches radius, with a silver limb, and telescopes which magnify from twelve to sixteen times ;

A *snuff box sextant by Troughton*, of two inches radius, with a nonius divided into minutes, telescopes which magnify four times, and an artificial horizon of crystal. This small instrument is very useful for travellers when forced in a boat to lay down the sinuosities of a river, or take angles on horseback without dismounting ;

A *reflecting and repeating circle by Le Noir*, of twelve inches diameter, with a mirror of platinum\* ;

A *theodolite by Hurter*, the azimuth circle of which was eight inches in diameter ;

An *artificial horizon by Caroché*, of plane glass, six inches in diameter, with an air-bubble level, the divisions of which are equivalent to two sexagesimal records ;

A *quadrant by Bird*, with a radius of a foot, furnished with a double division of the limb into ninety and ninety-six degrees, the micrometer screw indicating two sexagesimal seconds ;

\* I have compared in another place the advantages and disadvantages, in long journeys, of the reflecting instruments and astronomical repeating circles. (*Astron. Observ. Introd.* t. i, p. 17.)



the perpendicularity of the plane capable of being determined by means of a plummet and a large air-bubble level ;

A *graphometer* by *Ramsden*, placed on a cane, with a magnetic needle, and a wire meridian to take magnetical azimuths ;

A *dipping needle* of twelve inches, constructed on the principles of *Borda* and *Le Noir*. This instrument, of the most perfect execution, was ceded to me, at the time of my departure, by the French board of longitude. The figure of this instrument will be found in the narrative of the voyage of *d'Entrecasteaux* \*, the astronomical part of which was composed by a learned navigator, *Mr. de Rossel*. An azimuth circle serves to find the plane of the magnetic meridian, either by correspondent dips, or by seeking the position in which the needle is vertical, or observing the minimum of the dippings. The instrument is verified by observing on the east and west side, and changing the poles ;

A *variation compass* by *Le Noir*, constructed on the principles of *Lambert*, and furnished with a wire meridian. The nonius was divided at every two minutes ;

A *needle* twelve inches long, furnished with *sight-vanes*, and suspended to an untwisted thread according to the method of *Coulomb*.



This apparatus, like the *magnetic telescope of Prony*, served me to determine the small hourly variations of the magnetic variation, and the intensity of the forces which change with the latitudes. The oscillations of the great magnetic dipping needle of Mr. Le Noir give also a very exact measure of this last phenomenon.

A *magnetometer of Saussure\**, constructed by Mr. Paul at Geneva, with a limb that corresponds to an arch of three feet radius ;

An *invariable pendulum*, constructed by Mr. Megnie, at Madrid ;

Two *barometers by Ramsden* ;

Two *barometrical apparatuses*†, with the aid of which we find the mean height of the barometer, by successively plunging into a vessel several glass tubes, filled with mercury, closed at one end by a steel screw, and placed in a metal case ;

Several *thermometers by Paul, Ramsden, Megnie, and Fortin* ;

Two *hygrometers of Saussure and Deluc*, of hair and whalebone ;

Two *electrometers of Bennet and Saussure*, of

\* This magnetometer, which I found inaccurate, the theodolite, and reflecting circle, are the only instruments which I could not embark with me at Corunna.

† I have described this apparatus in the *Journal de Physique*, t. xlvii, p. 468, and in my *Observ. Astron.* t. i, p. 366:

gold leaf and elder pith, furnished with conductors four feet long, to collect, according to the method prescribed by Mr. Volta, the electricity of the atmosphere, by means of an ignited substance which yields smoke ;

A *cyanometer by Paul*. To give me the means of comparing with some certainty the blue colour of the sky, as it is seen on the summit of the Alps and the Cordilleras, Mr. Pictet had this cyanometer coloured conformably to the division of that which Mr. de Saussure made use of at the top of Mount Blanc, and during his memorable abode at the Col du Geant ;

An *eudiometer of Fontana*, for nitrous gas ; without strictly knowing how many parts of this gas are necessary to saturate a portion of oxygen, we may still precisely determine the quantity of atmospheric azote, and consequently the purity of the air, by employing, beside the nitrous gas, the oxygenated muriated acid, or a solution of sulphat of iron. Volta's eudiometer, though the most exact of any, is embarrassing for travellers, who traverse damp countries, on account of the small electric discharge, which the inflammation of oxygen and hydrogen gasses requires. The most portable eudiometrical apparatus, the most speedy and most eligible in every respect, is that pub-

lished by Mr. Gay-Lussac in the memoirs of the society of Arcueil\* ;

A *phosphoric eudiometer* by *Reboul*. By the nice researches of Mr. Thenard, on charcoal mixed with phosphorus, it is proved, that the slow action of this acidifiable basis† yields results less exact than strong combustion ;

An *apparatus* by *Paul*, proper to determine with the greatest precision the *degree* at which water boils at different heights, above the level of the ocean. The thermometer with a double nonius had been constructed from the apparatus, which Mr. de Saussure employed in his excursions ;

A *thermometrical lead* by *Dumotier*, consisting of a cylindric vase, furnished with two conical valves, and enclosing a thermometer ;

Two *areometers* of *Nicholson* and *Dollond* ;

A *compound microscope* of *Hofmann*, described in the history of the Cryptogamiæ by Mr. Hedwig ; a *standard metre* by *Le Noir* ; a *land surveyor's chain* ; an *assay balance* ; a *rain gauge* ; *tubes of absorption* to indicate small quantities of carbonic acid and oxygen, by means of lime-water, or a solution of sulphuret of potash ; some *Haiüy's electroscopical apparatuses* ;

\* Vol. 2, p. 235. See also the memoirs in the composition of the air which I published conjointly with Mr. Gay-Lussac in the Journal de Physique, vol. lix, p. 129, and my Zoological Observations, vol. i, p. 256.

† Bulletin of the Philomathic Society, 1812, No. 37, p. 93.

vases to measure the quantity of the *evaporation* of liquids in the open air; a mercurial *artificial horizon*; small *Leyden phials*, to be charged by rubbing; *galvanic apparatus*; *reagents* to try some experiments on the chemical composition of mineral waters, and a great number of small tools necessary for travellers to repair such instruments as might be deranged from the frequent falls of the beasts of burden.

We spent two days at Corunna, after our instruments were embarked. A thick fog, which covered the horizon, at length indicated the change of weather we so anxiously desired. On the 4th of June, in the evening, the wind turned to the north east, a point, which, on the coast of Galicia, is considered very constant during the summer. The Pizarro prepared to sail on the 5th, though we had intelligence but a few hours before, that an English squadron had been hailed from the watch tower of Sisarga, appearing to stand towards the mouth of the Tagus. Those who saw our ship weigh anchor, asserted that we should be captured in three days, and that, forced to follow the fate of the vessel, we should be carried to Lisbon. This prognostic gave us the more uneasiness, as we had known some Mexicans at Madrid, who, in order to return to Vera-Cruz, had embarked three times at Cadiz,



and who, having been each time taken at the entrance of the port, were obliged to return to Spain through Portugal.

The Pizarro set sail at two in the afternoon. As the long and narrow passage by which a ship sails from the port of Corunna opens towards the north, and the wind was contrary, we made eight short tacks, three of which were useless. A fresh tack was made, but very slowly, and we were for some moments in danger at the foot of the fort St. Amarro; the current having driven us very near the rock, on which the sea breaks with considerable violence. We remained with our eyes fixed on the castle of St. Antony, where the unfortunate Malaspina\* was then a captive in a state prison. On the point of leaving Europe to visit the countries which this illustrious traveller had visited with so much advantage, I could have wished to have fixed my thoughts on some object less affecting.

At half past six we passed the Tower of Hercules, which is the lighthouse of Corunna, as we have already mentioned, and where, from the remotest times, a coal fire is kept up for the direction of vessels. The light of this fire is no way proportionate to the beautiful construction of so vast an edifice; being so weak, that the ships cannot perceive it till they are in danger of striking

\* *Essai Politique sur le Mexique*, t. i, p. 338. *Observ. Astron.* t. i, p. 34.



on the shore. Towards the close of day, the wind increased, and the sea ran high. We directed our course to the north-west, in order to avoid the English frigates, which we supposed were cruising off those coasts. About nine we spied the light of a fishing hut, at Sisarga, which was the last object we beheld in the west of Europe. As we advanced, this feeble light mingled itself with the stars, which rose on the horizon; and our eyes remained involuntarily fixed on this object. Such impressions are not easily effaced from the memory of those who have undertaken long voyages, at an age when the emotions of the heart are in full vigour. How many remembrances are awakened in the imagination by a luminous point, which, in the midst of an obscure night, appearing at intervals above the swelling waves, points out the coast of our native home!

We were obliged to run under our courses, at the rate of ten knots, though the vessel was not constructed for making such way. At six in the morning the ship rolled so much, that the fore-top gallant mast was carried away, but without any disagreeable consequence. As we were thirteen days in our passage from Corunna to the Canary Islands, it was long enough to expose us to the danger of meeting English vessels, on stations so much frequented as the coasts of Portugal. No sail however appeared

in sight the first three days, which gave encouragement to the crew, who were no way prepared for fighting.

On the 7th we were in the latitude of Cape Finisterre. The group of granitic rocks, which forms part of this promontory, like that of Toriañes and Mont de Corcubion, bears the name of the Sierra de Toriñona. Cape Finisterre is lower than the neighbouring lands : but the Toriñona is visible at sea at 17 leagues distance, which proves that the elevation of its highest summit is not less than 300 toises (582 metres). The Spanish navigators pretend, that on these coasts the magnetic variation differs extremely from that observed at sea. Mr. Bory\*, it is true, in the voyage of the sloop *Amaranth*, found, in 1751, that the variation of the needle, determined at the Cape, was four degrees less than could have been conjectured from the observations made at the same period, along the coasts. In the same manner as the granite of Galicia contains tin disseminated in its mass, that of Cape Finisterre probably contains micaceous iron. In the mountains of the Upper Palatinate, there are indeed granitic rocks, in which crystals of micaceous iron take the place of common mica.

The 8th at sunset, we descried from the mast-

\* Mémoires de l'Académie des Sciences, 1768, p. 280.  
Fleurieu, Voyage de l'Isis, t. i, p. 225.

head an English convoy, which sailed along the coast, steering towards the south east. In order to avoid it, we altered our course during the night. From this moment no light was permitted in the great cabin, to prevent our being seen at a distance. This precaution, used on board all merchant-vessels, and prescribed in the regulations of the packet-boats of the royal navy, was extremely irksome to us during the passages we made in the course of the five following years. We were constantly obliged to make use of dark lanterns to examine the temperature of the water, or read the divisions on the limb of the astronomical instruments. In the torrid zone, where twilight lasts but a few minutes, our operations ceased almost at six in the evening. This state of things was so much the more displeasing to me, as from the nature of my constitution I never was subject to sea sickness, and feel an extreme ardour for study during the whole time I am at sea.

A voyage from the coast of Spain to the Canary Islands, and thence to South America, is scarcely attended with any event which deserves attention, especially when undertaken in summer. The navigation is often less dangerous than crossing one of the great lakes of Switzerland ; I shall therefore confine myself in this narrative to the general results of the magnetic and meteorological experiments, which I made in this

part of the ocean : and offer some observations, which may prove interesting to navigators. Whatever relates to the variations of the temperature of the air, and that of the sea, the hygrometrical state of the atmosphere, the blue colour of the sky, the inclination and intensity of the magnetic focus, will be found collected in my journal at the end of the third chapter, where it will be seen, from the detail and number of experiments, that we endeavoured to make the best use possible of the instruments with which we were furnished. It were to be wished, that the same observations could be repeated in the African and Asiatic seas, to indicate exactly the constitution of the atmosphere which covers the great basin of the waters.

The 9th of June, latitude  $39^{\circ} 50'$ , and longitude  $16^{\circ} 10'$  west of the meridian of the observatory of Paris, we began to feel the effects of the great current, which from the Azores directs itself towards the Straits of Gibraltar, and the Canary Islands. Comparing the place of our ship deduced from Berthoud's time-keeper with the pilot's reckoning, I was able to discover the smallest variations in the direction and velocity of the currents. From  $37^{\circ}$  to  $30^{\circ}$  of latitude, the vessel was sometimes carried in twenty-four hours, from eighteen to twenty-six miles to the east. The direction of the current was at first E by S, but nearer the Straits it became due



east. Captain Mackintosh, and one of the most distinguished navigators of our time, Sir Erasmus Gower, have noticed the modifications of this movement of the waters at different seasons of the year. Several pilots who frequent the Canary Islands have found themselves on the coasts of Lancerotte, when they expected to make good their landing on the Isle of Teneriffe. Mr. de Bougainville\*, in his passage from Cape Finisterre to the Canary Islands, found himself in sight of the Isle of Ferro, 4° more to the east than his reckoning indicated.

The current which is felt between the Azores, the southern coasts of Portugal, and the Canary Islands, is commonly attributed to that tendency towards the east, which the Straits of Gibraltar impress on the waters of the Atlantic Ocean. Mr. de Fleurieu, in notes added to the voyage of Captain Marchant†, observes even, that the Mediterranean, losing, by evaporation, more water than the rivers can supply, causes a movement in the neighbouring ocean, and that the influence of the Straits is felt at the distance of six hundred leagues. Without derogating from the sentiments of esteem which I owe to this celebrated navigator, from whose works I have derived much instruction, I may be permitted to consider this important object in a far more general point of view.

\* Voyage round the World, vol. i. p. 10.

† Vol. ii. p. 9 and 229.



When we cast our eyes over the Atlantic, or that deep valley which divides the western coasts of Europe and Africa from the eastern coasts of the new continent, we distinguish a contrary direction in the motion of the waters. Between the tropics, especially from the coasts of Senegal to the Caribbean Sea, the general current, that which was earliest known to mariners, flows constantly from east to west. This is called the Equinoctial current. Its mean rapidity, corresponding to different latitudes, is nearly the same in the Atlantic and in the Southern Ocean, and may be estimated at nine or ten miles in twenty-four hours, consequently from 0·59 to 0·65 of a foot every second \*! In those latitudes the waters run towards the west, with a velocity equal to a fourth of the rapidity of the greater part of the large rivers of Europe. The movement of the ocean, in a direction contrary to that of the rotation of the globe, is probably connected with this last phenomenon, only as far as the rotation changes the polar winds, which, in the low regions of the atmosphere, bring back the cold air of the high latitudes towards the equator, into

\* In comparing the observations which I had occasion to make in the two hemispheres, with those which are laid down in the voyages of Cook, La Pérouse, d'Entrescasteaux, Vancouver, Macartney, Krusenstern and Marchand, I found that the swiftness of the general current of the tropics, varies from 5 to 18 miles in twenty-four hours, or 0·3 to 1·2 feet each second.

trade winds\*. To this general impulsion, which these trade winds give the surface of the seas, we must attribute the equinoctial current, the force and rapidity of which are not sensibly modified by the local variations of the atmosphere.

In the channel which the Atlantic has dug between Guiana and Guinea, on the meridian of 20 or 23 degrees, from the 8th or 9th to the 2d or 3d degrees of northern latitude, where the trade winds are often interrupted by the winds which blow from the south, and south-south-west, the equinoctial current is more inconstant in it's direction. Towards the coasts of Africa, the vessels are drawn towards the south-east; whilst towards the Bay of All-saints and Cape St. Augustin, the coasts of which are dreaded by navigators who are sailing towards the mouth of the Plata, the general motion of the waters is masked by a particular current, the effects of which extend from Cape St. Roche to the Isle of Trinidad; and which runs north-west with a mean velocity of a foot or a foot and a half every second.

The equinoctial current is felt, though feebly, even beyond the Tropic of Cancer, in the 26th

\* Halley, on the cause of the general trade winds, in the *Philosoph. Trans. for the year 1735*, p. 58. Dalton, *Meteorolog. Exp. and Essays* 1793, p. 89. Laplace, *Explan. of the System of the World*, p. 227. The limits of the trade winds were for the first time, determined by Dampierre, in 1666.

and 28th degrees of latitude. In the vast basin of the Atlantic, at six or seven hundred leagues from the coasts of Africa, the vessels from Europe bound to the West Indies, find their sailing accelerated before they reach the torrid zone. More to the north, under 28 and 35 degrees, between the parallels of Teneriff and Ceuta, in 46 and 48 degrees of longitude, no constant motion is observed ; there, a zone of 140 leagues in breadth separates the equinoctial current, the tendency of which is towards the west, from that great mass of water which runs towards the east, and is distinguished for it's extraordinary high temperature. To this mass of waters, known by the name of the Gulf-stream\*, the attention of naturalists was directed in 1776 by the curious observations of Franklin, and Sir Charles Blagden. It's direction having lately become an important object of investigation among the English and American navigators, we must go farther back, to take a more general view of this phenomenon.

The equinoctial current drives the waters of the Atlantic towards the coasts inhabited by the Mosquito Indians, and towards those of Honduras. The New Continent, stretching from south to north, forms a sort of dyke to this cur-

\* Sir Francis Drake had already observed this extraordinary movement of the waters, but he was unacquainted with their elevated temperature.

rent. The waters are carried at first to the north-west, and passing into the Gulf of Mexico through the strait which is formed by False Cape and Cape St. Antonio, follow the bendings of the Mexican coast, from Vera Cruz to the mouth of the Rio del Norte, and thence to the mouths of the Mississippi, and the shoals to the west of the southern extremity of Florida. Having made this vast circuit to the west, the north, the east, and the south, the current takes a new direction towards the north, and throws itself with impetuosity into the Gulf of Florida. I there observed, in the month of May, 1804, in the 26th and 27th degrees of latitude, a celerity of eighty miles in twenty-four hours, or five feet every second, though at this period the north wind blew with great violence. At the end of the Gulf of Florida, in the parallel of Cape Canaveral, the Gulf-stream, or current of Florida, runs to the north-east. It's rapidity resembles that of a torrent, and is sometimes five miles an hour. The pilot may judge, with some certainty, of the error of his reckoning, and of the proximity of his approach towards New York, Philadelphia, or Charlestown \*, when he

\* The current of Florida flows at greater distances from the coasts of the United States, as it advances towards the north. It's position being exactly marked in the new maritime charts, the navigator finds the longitude of the vessel to half a degree, when he is on the brink of the current, where the eddy



reaches the edge of the stream ; for the elevated temperature of the waters ; their strong saltness, indigo-blue colour, and the shoals of sea-weed which cover the surface, as well as the heat of the surrounding atmosphere, sensible even in winter, all indicate the Gulf-stream. It's rapidity diminishes towards the north, at the same time that it's breadth increases, and the waters cool. Between Cayo Biscaino and the bank of Bahama\*, the breadth is only 15 leagues, whilst in the latitude of 28 degrees and a half, it is 17, and in the parallel of Charlestown, opposite Cape Henlopen, from 40 to 50 leagues. The rapidity of the current is from three to five miles an hour, where the stream is the narrowest, and is only one mile as it advances towards the north. The waters of the Mexican Gulf, forcibly drawn to the north-east, preserve their warm temperature to such a point, that at 40 and 41 degrees of latitude I found them at  $22\cdot5^{\circ}$  ( $18^{\circ}$  R.), when, out of the current, the heat of the ocean at it's surface was scarcely  $17\cdot5^{\circ}$  ( $14^{\circ}$  R.). In the parallel of New York and Oporto, the

begins, if he obtain a good observation for the latitude. This method is practised by a great number of captains of merchant ships who cross from Europe to North America.

\* *Journal of Andrew Ellicott, Commissioner of the United States, for determining the boundary on the Ohio and Mississippi, 1803, p. 260. Hydraulic and Nautical Observations on the Atlantic Ocean, by Gov. Pownall. (Lond. 1787.)*



temperature of the *Gulf-stream* is consequently equal to that of the seas of the tropics in the 18th degree of latitude ; as for instance, in the parallel of Porto Rico, and the islands of Cape Verd.

To the east of the port of Boston, and on the meridian of Halifax, under  $41^{\circ} 25'$  of latitude, and  $67^{\circ}$  of longitude, the current is near 80 leagues broad. From this point it turns suddenly to the east, so that it's western edge, as it bends, becomes the western limit of the running waters, skirting the extremity of the great bank of Newfoundland, which Mr. Volney ingeniously calls the bar of the mouth of this enormous sea river \*. The cold waters of this bank, which according to my experiments are at the temperature of  $8.7^{\circ}$  or  $10^{\circ}$  ( $7^{\circ}$  or  $8^{\circ}$  R.) present a striking contrast with the waters of the torrid zone, driven to the north by the *Gulf-stream*, the temperature of which is from  $21^{\circ}$  to  $22.5^{\circ}$  ( $7^{\circ}$  to  $18^{\circ}$  R.). In these latitudes, the caloric is distributed in a singular manner throughout the ocean ; the waters of the bank are  $9.4^{\circ}$  colder than the neighbouring sea ; and this sea is  $3^{\circ}$  colder than the current. These zones can have no equilibrium of temperature, having a source of heat,

\* Tableau du climat et du sol des Etats-Unis, T. i, p. 230, Romme, Tableau des Vents, des Marées et des Courants, T. i, p. 228.

or a cause of refrigeration, which is peculiar to each, and the influence of which is permanent\*.

From the bank of Newfoundland, or from the 52d degree of longitude to the Azores, the *Gulf-stream* continues its course towards the east, and the east-south-east. The waters still preserve a part of the impulsion they have received near a thousand leagues distance, in the straits of Florida, between the Isle of Cuba, and the shoals of Tortoise Island. This distance is double the length of the course of the river of the Amazons, from Jaen or the Straits of Manseriche to Grand Para. On the meridian of the Isles of Corvo and Flores, the most western of the group of the Azores, the breadth of the current is 160 leagues. When vessels, on their return from South America to Europe, endeavour to make these two islands to rectify their longitude, they constantly perceive the motion of the waters to the south-east. At the 33d degree of latitude the equinoctial current of the tropics is in the near vicinity of the *Gulf-stream*. In this part of the

\* In treating of the temperature of the ocean, we should carefully distinguish four very different phenomena ;—1st, the temperature of the water at it's surface corresponding to different latitudes, the ocean being considered as in repose; 2dly, the decrement of caloric in the successive strata of the water; 3dly, the effect of the deep shoals on the temperature of the ocean; 4thly, the temperature of the currents, which cause the waters of one zone to pass with acquired velocity across the motionless waters of another zone.

ocean, we may in a single day pass from waters that flow towards the west, into those which run to the south-east or east-south-east.

From the Azores, the current of Florida turns towards the straits of Gibraltar, the Isle of Madeira, and the group of the Canary Islands. The opening of the Pillars of Hercules has no doubt accelerated the motion of the waters towards the east. We may in this point of view assert, that the strait, by which the Mediterranean communicates with the Atlantic, produces it's effects at a great distance; but it is probable also, that, without the existence of this strait, the vessels which sail to Teneriff, would be driven to the south-east by a cause, which we must seek on the coasts of the New World. Every motion is the cause of another motion in the vast basin of the seas as well as in the aerial ocean. Pursuing the currents to their most distant sources, and reflecting on their variable celerity, sometimes decreasing as between the Gulf of Florida and the bank of Newfoundland; at other times augmenting, as in the neighbourhood of the Straits of Gibraltar, and near the Canary Islands, we cannot doubt but the same cause which drives the waters to make the circuitous sweep, of the Gulf of Mexico, agitates them also near the Isle of Madeira.

It is to the south of this island, that we can follow the current, in it's direction to the S. E.

and S. S. E. towards the coast of Africa, between Cape Cantin and Cape Bojador. In these latitudes a vessel becalmed is carried on the coast, at the time it is thought at a great distance, if the reckoning be not corrected. Were the motion of the waters caused by the opening at the Straits of Gibraltar, why, on the south of these Straits, should it not follow an opposite direction? On the contrary, in the 25th and 26th degrees of latitude, the current flows at first directly to the south, and then to the south-west. Cape Blanc, which, after Cape Verd, is the most salient promontory, seems to have an influence on this direction, and it is in this parallel that the waters, of which we have followed the course from the coasts of Honduras to those of Africa, mix with the great current of the tropics to begin their tour from east to west. We have already observed, that, several hundred leagues to the west of the Canary Islands, the motion which is peculiar to the equinoctial waters is felt in the temperate zone from the 28th and 29th degrees of northern latitude; but on the meridian of the Island of Ferro, the vessels reach the south as far as the tropic of Cancer, before they find themselves, by their reckoning, to the east of their true position.

I hope to have given some value to the chart\*

\* This chart which I began to sketch in October, 1804, beside the temperature of the sea, furnishes observations on the



of the Northern Atlantic Ocean, which I have published, by tracing in it with particular care the direction of this retrograde current, that like a river, the bed of which is gradually enlarged, traverses the vast extent of the sea. I flatter myself that the navigators, who have studied the charts of Jonathan Williams, of Governor Pownall, of Heather, and of Strickland \*, will find several objects in mine worthy of their attention. Independent of the observations I have made during six voyages, namely, from Spain to Cumana, from Cumana to the Havannah, from the Isle of Cuba to Carthagena in America, from Vera Cruz to the Havannah, from this port to Philadelphia, and from Philadelphia to the coasts of France, I have collected in this map all that my laborious and active exertions could discover in the journals of such authors, as have been able to make use of astronomical means to determine the effect of the currents. I have indicated also the latitudes, in which the motion of the waters is not constantly perceived ; for in the same manner as the northern limit of the current of the tro-

dip of the magnetic needle, the lines without variation, the intensity of the magnetic forces, the stripes of floating sea weeds, and other phenomena which interest physical geography.

N.B. This chart, not yet engraved, will be published in the succeeding volumes.

\* Amer. Trans. vol. ii, p. 328 ; vol. iii, p. 82 and 194 ; vol. v, p. 90 ; and an interesting essay on the currents, by Mr. Delam  therie. Journ. de Phys. 1808, t. 67, p. 91.



pics and that of the trade winds vary according to the seasons, the Gulf-stream also changes its place and direction. These changes become very perceptible from the 38th degree of latitude as far as the great bank of Newfoundland, and are observed even between the 48th degree of longitude west of Paris, and the meridian of the Azores. The variable winds of the temperate zone, and the melting of the ice of the northern pole, whence in the months of July and August a great quantity of fresh water flows towards the south, may be considered as the principal causes, which modify in these high latitudes, the force and direction of the Gulf-stream.

We have just seen that between the parallels of 11 and 43 degrees, the waters of the Atlantic are drawn on by the currents in a continual whirlpool. Supposing that a molecule of water returns to the same place from which it departed, we can estimate, from our present knowledge of the swiftness of currents, that this circuit of 3800 leagues is not terminated in less than two years and ten months. A boat, which may be supposed to receive no impulsion from the winds, would require thirteen months from the Canary islands to reach the coast of Caraccas, ten months to make the tour of the Gulf of Mexico and reach Tortoise Shoals opposite the port of the Havannah, while forty or fifty days might be sufficient to carry it from the Straits of Florida to the

bank of Newfoundland. It would be difficult to fix the rapidity of the retrograde current from this bank to the coasts of Africa: estimating the mean velocity of the waters at seven or eight miles in twenty-four hours, we find ten or eleven months for this last distance. Such are the effects of this slow but regular motion, which agitates the waters of the ocean. Those of the river of the Amazons take nearly forty-five days to flow from Tomependa to Grand Para.

A short time before my arrival at Teneriff, the sea had left in the road of St. Croix a trunk of a *cedrela odorata* covered with the bark. This American tree vegetates exclusively under the tropics, or in the neighbouring regions. It had no doubt been torn up on the coast of the continent, or of that of Honduras. The nature of the wood, and the lichens which covered it's bark, were evident proofs, that this trunk did not belong to these submarine forests, which ancient revolutions of the globe have deposited in lands transported from the polar regions. If the *cedrela*, instead of having been thrown on the strand of Teneriff, had been carried farther south, it would probably have made the whole tour of the Atlantic, and returned to it's native soil with the general current of the tropics. This conjecture is supported by a fact of more ancient date, recorded in the general history of the Canaries by the Abbé Viera. In 1770, a small vessel laden

with corn, and bound from the Island of Lance-rotte, to Santa Cruz, in Teneriff, was driven to sea, while none of the crew were on board. The motion of the waters from east to west, carried it to America, where it went on shore at La Guayra near Caraccas \*.

Whilst the art of navigation was yet in it's infancy, the Gulf-stream furnished the genius of Christopher Columbus with certain indications of the existence of western regions. Two corpses, the features of which indicated a race of unknown men, were thrown on the coasts of the Azores, towards the end of the 15th century. Nearly at the same period, the brother-in-law of Columbus, Peter Correa, governor of Porto Santo, found on the strand of this island pieces of bamboo of an extraordinary size, brought thither by the western currents†. These corpses and the bamboos attracted the attention of the Genoese navigator, who conjectured, that both came from a continent situate towards the west ; we know at present, that in the torrid zone the trade winds and the current of the tropics are in opposition to every motion of the waves in the direction of the earth's rotation. The productions of the new world cannot reach the old, but by the very high latitudes, and in following the direc-

\* Viera Hist. gen. de las Islas Canarias, t. ii, p. 167.

† Munoz, Hist. del nuevo mundo, Lib. ii, §. 14. Fernan Colon, vida del Almirante, cap.9. Herera Decad. 1, cap. ii

tion of the current of Florida. The fruits of several trees of the Antilles are often thrown on the coasts of the Isles of Ferro and Gomera. Before the discovery of America, the Canarians considered these fruits as coming from the enchanted isle of St. Borondon, which according to the reveries of the pilots, and certain legends, was placed towards the west in an unknown part of the ocean, buried, as was supposed, in eternal fogs.

My chief view in tracing a sketch of the currents of the Atlantic is to prove, that the motion of the waters towards the south-east, from Cape St. Vincent to the Canary Islands, is the effect of the general motion, which the surface of the Ocean feels at it's western extremity. We shall give but a very succinct account of the arm of the *Gulf-stream*, which in the 45th and 50th degrees of latitude, near the bank of Bonnet-Flamand, runs from the south-west to the north-east towards the coasts of Europe. This partial current becomes very strong when the winds have continued to blow a long time from the west : and, like that which flows along the isles of Ferro and Gomera, deposits every year on the western coasts of Ireland and Norway the fruit of trees, which belong to the torrid zone of America. On the shores of the Hebrides, we collect seeds of *mimosa scandens*, of *dolichos urens*, of *guilandina bonduc*, and several other plants of



Jamaica, the Isle of Cuba, and of the neighbouring continent\*. The current carries thither also barrels of French wine, well preserved, the remains of the cargoes of vessels wrecked in the West Indian Seas†. To these examples of the distant migration of the vegetable world, others no less striking may be added. The wreck of an English vessel, the *Tilbury*, burnt near Jamaica, was found on the coasts of Scotland. On these same coasts various kinds of tortoises are sometimes found, that inhabit the waters of the Antilles. When the western winds are of long duration, a current is formed in the high latitudes, which runs directly towards the east-south-east, from the coasts of Greenland and Labrador, as far as the north of Scotland. Wallace relates, that twice, in 1682 and 1684, American savages of the race of the Esquimaux, driven out to sea in their leathern canoes, during a storm, and left to the guidance of the currents, reached the Orcades‡. This last example is so much the more worthy of attention, as it proves at the

\* Pennant, *Voyage to the Hebrides*, 1772, p. 232. Gunner's *Acta Nidrosiensia*, t. ii, p. 310. Sloane, in the *Philos. Trans.* No. 222, p. 398. Linn. *Amæn. Acad.* vol. ii. p. 477.

† *Necker*, *View of Nature in the Hebrides*, in the *Bibl. Brit.* vol. xlii, p. 90.

‡ James Wallace, (of Kirkwall) *Account of the Islands of Orkney*, 1700, p. 60. Fischer, in *Pallas, Neue Nordische Beiterge*, B. iii, p. 320. Greenlanders have been seen in the islands of Eda and Westram.



same time how, at a period when the art of navigation was yet in it's infancy, the motion of the waters of the ocean would contribute to disseminate the different races of men over the face of the globe.

The small portion of knowledge, which we hitherto possess with respect to the absolute position and breadth of the *Gulf-stream*, as well as it's prolongation towards the coasts of Europe and Africa, has been accidentally observed by a small number of enlightened men, who have crossed the Atlantic in different directions. As the knowledge of the currents is of the highest importance to shorten navigations, it would be no less useful to the pilot than the naturalist, that vessels, furnished with excellent chronometers, should cruise in the Gulf of Mexico, and in the Northern Ocean between the 30th and 54th degrees of latitude, in order to determine at what distance the *Gulf-stream* is found in different seasons, and under the influence of different winds, to the south of the mouth of the Mississippi, and to the east of Capes Hatteras and Cod. The same navigators might have instructions to examine whether the great current of Florida constantly skirts the southern bank of Newfoundland; and on what parallel, between 32 and 40 degrees of west longitude, the waters, which run from east to west are nearest those which follow an opposite direction.

The solution of this last problem becomes so much the more important, as the latitudes which we have just indicated are traversed by the greater part of the vessels, which return to Europe from the West India islands, or the Cape of Good Hope. Beside the direction and swiftness of the currents, this expedition would serve to discover the temperature of the sea at its surface, the lines without variation, the dip of the needle, and the intensity of the magnetic forces. Observations of this kind become extremely valuable, when the position of the place where they were made has been determined by astronomical means. In the seas most frequented by the Europeans, far out of sight of land, an able navigator may still devote his time to important labours. The discovery of a group of uninhabited islands is less interesting than the knowledge of those laws, which link together a considerable number of insulated facts.

In reflecting on the causes of the currents, we find, that they are much more numerous than is generally believed; for the waters of the sea may be put in motion by an external impulse, by a difference in heat and saltness, by the periodical melting of the polar ice, or by the inequality of the evaporation, which takes place in different latitudes. Sometimes several of these causes concur to the same effect, and sometimes they produce effects that are contrary. Winds

that are light, but which, like the trade winds, are continually acting on the whole of a zone, cause a real movement of transition, which we do not observe in the heaviest tempests, because these last are circumscribed within a small space. When, in a great mass of water, the particles placed at the surface acquire a different specific gravity, a superficial current is formed, which takes it's direction towards the point where the water is coldest, or that which is most saturated with muriat of soda, sulphat of lime, and with muriat or sulphat of magnesia. In the seas of the tropics we find, that at great depths the thermometer marks 7 or 8 centesimal degrees. Such is the result of the numerous experiments of Commodore Ellis and of Mr. Peron. The temperature of the air in those latitudes being never below 19 or 20 degrees, it is not at the surface that the waters can have acquired a degree of cold so near the point of congelation, and of the maximum of the density of water. The existence of this cold strata in the low latitudes is an evident proof of the existence of an inferior current, which runs from the poles towards the equator : it also proves, that the saline substances, which alter the specific gravity of the water, are distributed in the ocean, so as not to annihilate the effect produced by the differences of temperature\*.

\* In fact, if the mean saltness of the sea was 0.005 greater

Considering the velocity of the molecules, which, on account of the rotatory motion of the globe, vary with the parallels, we may be tempted to admit that every current, in the direction

under the equator than in the temperate zone, as several naturalists pretend, a current at the bottom, from the equator towards the pole, would be the result : for 0·005 produce a difference of density of 0·0017, while, according to the tables of Hallstrom, a refrigeration of 16 centesimal degrees, between the 20th and 4th of temperature, causes only a change of 0·00015 in the specific gravity. After attentive examination of the results of the experiments of Black, reduced by Mr. Kirwan to the temperature of 16°, I find on the average the density of the water of the sea,

from 0° to 14° latitude	at 1·0272
from 15° to 25°	1·0282
from 30° to 44°	0·0278
from 54° to 60°	1·0271

The proportion of salt corresponding to these four zones are, according to Bishop Watson, 0·0374 ; 0·0394 ; 0·0386 ; and 0·0372. Those numbers sufficiently prove, that the experiments hitherto published do not in any way justify the renewed opinion, that the sea is salter under the equator than under the 30th and 44th degrees of latitude. It is not therefore a greater quantity of saline substance held in solution, which opposes itself to this inferior current, by which the equinoctial ocean receives particles of water, which during the winter of the temperate zones have sunk towards the bottom of the sea, from the 30th to the 44th degree of southern and northern latitude. Baumé has analysed the sea-water collected by Mr. Pagès in different latitudes, and found in this water 0·005 less salt at 1° 16' of latitude than between the 25th and 40th degrees. (*Kirwan's Geol. Essays*, p. 350. *Pagès Voyage round the World*, vol. ii, p. 6 and 275.)



from south to north, tends at the same time toward the east, while the waters, which run from the pole toward the equator, have a tendency to deviate toward the west. We may also be led to think, that these tendencies diminish to a certain point the speed of the tropical current, in the same manner as they change the direction of the polar current, which in July and August, is regularly perceived during the melting of the ice, on the parallel of the bank of Newfoundland, and farther north. Very old nautical observations, which I have had occasion to confirm by comparing the longitude given by the chronometer with that which the pilots obtained by their reckoning, are contrary to these theoretical ideas. In both hemispheres, the polar currents, when they are perceived, decline a little to the east; and we think that the cause of this phenomenon should be sought in the constancy of the westerly winds which prevail in the high latitudes. Besides, the particles of water do not move with the same rapidity as the particles of air; and the currents of the ocean, which we consider as the most rapid, have only a swiftness of eight or nine feet a second: it is consequently very probable, that the water, in passing through different parallels, gradually acquires a velocity correspondent to those parallels, and that the rotation of the Earth does not change the direction of the currents.



The variable pressures, which the surface of the sea undergoes by the changes in the weight of the air, are another cause of motion which deserves particular attention. It is well known, that the barometric variations do not in general take place at the same moment on two distant points, which are on the same level. If in one of these points the barometer stands a few lines lower than in the other, the water will rise where it finds the least pressure of the air, and this local intumescence will continue, till, from the effect of the wind, the equilibrium of the air is restored. Mr. Vaucher thinks that the tides in the Lake of Geneva, known by the name of the *seiches*, arise from the same cause. Under the torrid zone, the horary variations of the barometer may produce small oscillations at the surface of the seas, the meridian of 4<sup>h</sup>, which corresponds to the minimum of the pressure of the air, being situate between the meridian of 21<sup>h</sup> and 11<sup>h</sup> upon which the height of the mercury is the greatest; but these oscillations, if even they were perceptible, will be accompanied by no change of place\*.

When this last movement is produced by the inequality of the specific weight of the particles, a double current is formed, the upper of which has a contrary direction to the lower. Thus in the greatest part of the straits, as in the seas of

\* Mouvement de translation.

the tropics, which receive the cold waters of the northern regions, the whole mass of water is agitated to a very great depth. We are ignorant if it be the same, when the movement of progression, which must not be confounded with the oscillation of the waves, is the effect of an external impulse. Mr. de Fleurieu, in his narrative of the voyage of the *Isis* \*, cites several facts which render it probable that the sea is much less still at the bottom than naturalists generally admit. Without entering here into a discussion which we shall treat hereafter, we shall only observe, that if the external impulse is constant in it's action, like that of the trade winds, the friction of the particles of water on each other must necessarily propagate the motion of the surface of the ocean even to the inferior strata ; and in fact this propagation in the Gulf-stream has long been admitted by navigators, who think they discover the effects in the great depth of the sea wherever it is traversed by the current of Florida, even amidst the sand-banks which surround the northern coasts of the United States. This immense river of hot waters, after a course of fifty days, from the 24th to the 45th degree of latitude, or 450 leagues, does not lose, amidst the rigors of winter in the temperate zone, more than 3 or 4 degrees of the tem-

\* Voyage made by order of the king, in 1768 and 1769, to try the marine time-pieces. Vol. i, p. 513.

perature it had under the tropics. The greatness of the mass, and the small conductibility of water for heat, prevent a more speedy refrigeration. If therefore the Gulf-stream has dug a channel at the bottom of the Atlantic ocean, and if its waters are in motion to considerable depths, they must also in their inferior strata keep up a lower temperature than that which is observed in the same parallel, in a part of the sea which has neither currents nor deep shoals. These questions can be cleared up only by direct experiments, made by thermometrical soundings.

Sir Erasmus Gower remarks, that, in the passage from England to the Canary Islands, the current, which draws the vessels towards the south-east, begins at the 39th degree of latitude. During our navigation from Corunna to the coasts of South America, the effect of this motion of the waters was perceived farther to the north. From the 37th to the 30th degree, the deviation was very unequal; the daily average effect was 12 miles, that is, our sloop drove towards the east 75 miles in six days. In cutting the parallel of the Strait of Gibraltar, at a distance of 140 leagues, we had occasion to observe, that in those latitudes, the maximum of the rapidity does not correspond with the mouth of the Strait, but with a more northerly point, which lies in the prolongation of a line passing through the Strait and Cape St. Vincent. This line is parallel

to the direction which the waters follow from the Azores to Cape Cantin. We should moreover observe, (and this fact is not uninteresting to those who examine the nature of fluids) that in this part of the retrograde current, on a breadth of 120 or 140 leagues, the whole mass of water has not the same rapidity, nor does it follow precisely the same direction. When the sea is perfectly calm, there appears at the surface narrow stripes, like small rivulets, in which the waters run with a murmur very sensible to the ear of an experienced pilot. The 13th of June, in  $34^{\circ} 36'$  of northern latitude, we found ourselves in the midst of a great number of these beds of currents. We took their direction with the compass; some ran north-east, others east-north-east, though the general movement of the ocean, indicated by comparing the reckoning with the chronometrical longitude, continued to be south-east. It is very common to see a mass of motionless waters crossed by threads of water, which run in different directions, and we may daily observe the phenomenon on the surface of lakes; but it is much less frequent to find partial movements, impressed by local causes on small portions of waters in the midst of a sea-river, which occupies an immense space, and which moves, though slowly, in a constant direction. In the conflict of currents, as in the oscillation of the waves, our imagination is struck by those

movements which seem to penetrate each other, and by which the ocean is continually agitated.

We passed Cape St. Vincent, which is of basaltic formation, at more than eighty leagues distance. It is not distinctly seen at a greater distance than 15 leagues, but the granitic mountain called the Foya de Monchique, situate near the Cape, is perceptible, as the pilots pretend, at the distance of 26 leagues \*. If their assertion be exact, the Foya is 700 toises (1363 metres) and consequently 116 toises (225 metres) higher than Vesuvius. It seems extraordinary that the Portuguese government should neglect to maintain a fire on this point, which must be made by every vessel coming from the Cape of Good Hope or Cape Horn, and is an object for which they look with the greatest eagerness. Between Ferrol and Cadiz there is but one single light-house, that of Cape la Rocque, to direct the mariners on coasts where the approach is so dangerous. The fires on the Tower of Hercules and Cape Spichel are so feeble, and so little visible at a distance, that they scarcely deserve to be cited. Besides, the convent of the Capuchins, which rises above Cape St. Vincent, would be one of the fittest places to build a light-house, with a rotatory light like that of Cadiz, or the mouth of the Garonne.

\* *Elementos de Navigacion de Don Dionisio Macarte*, p. 47. *Borda, Voy. de la Flore*, vol. i, p. 39, pl. 2. *Link and Hoffmanssegg. Voy. en Portugal*, vol. ii, p. 128; vol. iii, p. 323.



From Corunna to the 36th degree of latitude we had scarcely seen any organic being, excepting sea-swallows, and a few dolphins. We looked in vain for sea weeds (*fucus*) and molluscas, when on the 11th of June we were struck with a curious sight, which afterwards was frequently renewed in the southern ocean. We entered on a zone where the whole sea was covered with a prodigious quantity of medusas. The vessel was almost becalmed, but the molluscas were borne towards the south-east, with a rapidity four times that of the current. Their passage lasted near three quarters of an hour. We then perceived but a few scattered individuals, following the crowd at a distance as if they were tired with their journey. Do these animals come from the bottom of the sea, which is perhaps in these latitudes some thousand fathoms deep? or do they make distant voyages in shoals? We know that the molluscas haunt banks; and if the eight rocks, near the surface, which Captain Vobonne asserts having seen in 1732, to the north of Porto Santo, really exist, we may suppose that this innumerable quantity of medusas had been thence detached; for we were but 28 leagues from this reef. We found, beside the medusa aurita of Baster, and the medusa pelagica of Bosc with eight tentacula (*pelagia denticulata*, Peron), a third species which resembles the medusa hysocella, and which Vandelli found at the

mouth of the Tagus. It is known by it's brownish-yellow colour, and by it's tentaculæ, which are longer than the body. Several of these sea-nettles were four inches in diameter: their reflection was almost metallic: their changeable colours of violet and purple formed an agreeable contrast with the azure tint of the ocean.

In the midst of these medusas Mr. Bonpland observed bundles of *dagysa notata*, a mollusca of a singular construction, which Sir Joseph Banks first discovered. These are small gelatinous bags, transparent, cylindrical, sometimes polygonal, which are thirteen lines long and two or three in diameter. These bags are open at both ends. In one of these openings, we observed a hyaline bladder, marked with a yellow spot. The cylinders are longitudinally placed on each other, like the cells of a bee-hive, and form chaplets from six to eight inches in length. I tried the galvanic electricity on these molluscas, but it produced no contraction. It appears that the genus *dagysa*, formed at the time of Cook's first voyage, belongs to the salpas (biphores of Bruguière) to which Mr. Cuvier joins the *thalia* of Brown, and the *tethis vagina* of Tilesius. The salpas journey also by groups, joining in chaplets, as we have observed of the *dagysa* \*.

\* Account of Voyages undertaken by order of his Britannic Majesty, 1789, vol. iii, p. 261. Ann. du Museum, vol. xiv, p. 360.

The morning of the 13th of June, in  $34^{\circ} 33'$  latitude, we saw large masses of this last mollusca in it's passage, the sea being perfectly calm. We observed during the night, that, of three species of medusas which we collected, none yielded any light but at the moment of a very slight shock. This property does not belong exclusively to the medusa noctiluca, which Forskæl has described in his *Fauna Ægyptiaca*, and which Gmelin has applied to the medusa pelagica of Lœffling, notwithstanding it's red tentacula, and the brownish tuberosities of it's body. If we place a very irritable medusa on a pewter plate, and strike against the plate with any sort of metal, the small vibrations of the plate are sufficient to make this animal emit light. Sometimes in galvanising the medusa, the phosphorescence appears at the moment that the chain closes, though the excitors are not in immediate contact with the organs of the animal. The fingers with which we touch it remain luminous for two or three minutes, as is observed in breaking the shell of the pholades. If we rub wood with the body of a medusa, and the part rubbed ceases shining, the phosphorescence returns if we pass a dry hand over the wood. When the light is extinguished a second time, it can no longer be reproduced, though the place rubbed be still humid and viscous. In what manner ought we to consider the effect of the friction, or that of the

shock? This is a question of difficult solution. Is it a slight augmentation of temperature which favours the phosphorescence? or does the light return, because the surface is renewed, by putting the animal parts proper to disengage the phosphoric hydrogen in contact with the oxygen of the atmospheric air? I have proved by experiments published in 1797, that the shining of wood is extinguished in hydrogen gas, and in pure azotic gas, and that it's light reappears whenever we mix with it the smallest bubble of oxygen gas. These facts, to which we shall hereafter add several others, lead to the discovery of the causes of the phosphorescence of the sea, and of that peculiar influence, which the shock of the waves exercises on the production of light.

When we were between the Isle of Madeira and the coasts of Africa, we had slight breezes and dead calms, very favourable for the magnetic observations, which occupied me during this passage. We were never wearied of admiring the beauty of the nights; nothing can be compared to the transparency and serenity of an African sky. We were struck with the innumerable quantity of falling stars, which appeared at every instant. The farther progress we made toward the south, the more frequent was this phenomenon, especially near the Canaries. I have observed during my excursions, that these

igneous meteors are in general more common and luminous in some regions of the globe than in others ; I have never beheld them so multiplied as in the vicinity of the volcanoes of the province of Quito, and in the part of the Pacific Ocean which bathes the volcanic coasts of Guatemala. The influence, which place, climate, and seasons appear to have on the falling stars, distinguishes this class of meteors from those which give birth to stones that fall from the sky (aerolites), and which probably exist beyond the boundaries of our atmosphere. According to the corresponding observations of Messrs. Benzenberg and Brandes \*, many of the falling stars seen in Europe were only thirty thousand toises high. One was even measured which did not exceed fourteen thousand toises, or five leagues. These measures, which can give no result but by approximation, deserve well to be repeated. In warm climates, especially under the tropics, the falling stars leave a tail behind them, which remains luminous 12 or 15 seconds : at other times they seem to burst into sparks, and they are generally lower than those in the north of Europe. We perceive them only in a serene and azure sky ; they have perhaps never been seen below a cloud. Falling stars often follow the same direction for several hours,

\* Gilbert. *Annalen de Physik*, th. xii, p. 368.



which direction is then that of the wind \*. In the Bay of Naples M. Gay-Lussac and myself observed luminous phenomena, very analogous to those which fixed my attention during a long abode at Mexico and Quito. These meteors are perhaps modified by the nature of the soil and the air, like certain effects of the looming † and of the terrestrial refraction peculiar to the coasts of Calabria and Sicily.

During our navigation we saw neither the Desert Islands nor Madeira ; I should have wished to have had the means of verifying the longitude of those islands, and of taking the angles of altitude of the volcanic mountains, which rise to the north of Funchal. M. Borda ‡ says, that these mountains are seen at 20 leagues distance, which would give a height of only 414 toises (806 metres); but we know by recent measures, that the most elevated point § of Ma-

\* Such is the result of numerous observations by Mr. Arago, who, at the period of the prolongation of the meridian in Spain, was enabled to observe the direction of the meteors, during whole nights, on the Tosal d'Encanade, a mountain in the kingdom of Valencia.

† Mirage.

‡ Voy. de la Flore, vol. i, p. 65. The Salvage is visible at eight leagues ; the little Desert Islands are seen at 12 leagues distance. Borda, vol. i, p. 67 et 70.

§ Smith's Tour of the Continent, vol. i, p. 200. Irish Trans. vol. viii, p. 124. According to Heberden, the Peak Ruivo of Madeira is 595 toises above the plane which surrounds its basis. Cook's first Voyage, vol. i, p. 272.

deira is 5162 English feet, or 807 toises. The small Desert Islands and the Salvage, on which are gathered the archil and the mesembryanthemum crystallinum, are only 200 toises in perpendicular height. I think it useful to fix the attention of navigators on these measures, because, according to a method of which this narrative offers several examples, and which Borda, Lord Mulgrave, Mr. de Rossel, and Don Cosmo Churruca have successfully employed in their expeditions, we may, by angles of height taken with good reflecting instruments, discover with sufficient exactness the distance, at which a vessel finds itself from a cape, or an island with mountains.

When we were forty leagues east of the island of Madeira, a common swallow came and perched on the topsail-yard. It was so fatigued, that it suffered itself to be easily taken. What could engage a bird, in that season, and in calm weather, to fly so far? In the expedition of d'Entrecasteaux, a common swallow was seen at 60 leagues distance from Cape Blanc; but this was towards the end of October, and Mr. Labillardière thought it had newly arrived from Europe. We crossed these latitudes in June, at a period when the seas had not for a long time been agitated by tempests. I dwell on this last circumstance, because small birds, and even butterflies, are sometimes forced out to sea by the impetu-

osity of the winds, as we observed in the southern ocean, when we were on the western coasts of Mexico.

The Pizarro had orders to touch at the Isle of Lancerote (*Lanzarote*,) one of the seven great Canary Islands, to inquire whether the English blockaded the road of St. Croix of Teneriff. We had been uncertain, since the 15th of June, what course to follow. Till then the pilots, to whom the use of marine watches was not very familiar, had shown little confidence in the longitude which I obtained regularly twice a-day, by the difference of time, in taking horary angles morning and evening. They hesitated at steering to the south-east, in apprehension of running on Cape Nun, or at least of leaving the island of Lancerote to the west. At length on the 16th of June, at nine in the morning, when we were already in  $29^{\circ} 26'$  of latitude, the Captain changed his course, and sailed toward the east. The exactness of Lewis Berthoud's timekeeper was soon recognized: at two in the afternoon we had sight of land, which appeared like a small cloud at the edge of the horizon. At five, the sun being lower, the Isle of Lancerote presented itself so distinctly, that I was able to take the angle of altitude of a conic mountain, which towered majestically over the other summits, and which we thought was the great volcano which had committed so many ravages in the night of the first of September, 1730.

The current drew us toward the coast more rapidly than we wished. As we advanced, we discovered at first the island of Fortaventure (*Forteventura*) famous for the great number of camels \* which it feeds ; and a short time after we saw the small island of Lobos in the channel which separates Fortaventure from Lancerote. We spent part of the night on the deck. The moon illumined the volcanic summits of Lancerote, the flanks of which, covered with ashes, reflected a silver light. Antares threw out it's resplendent rays near the lunar disk, which was but a few degrees above the horizon. The night was beautifully serene and cool. Though we were but a little distance from the west of Africa, and on the limit of the torrid zone, the centigrade thermometer rose no higher than 18°. The phosphorescence of the ocean seemed to augment the mass of light diffused through the air. I was able to read for the first time the nonius of a sextant, by Troughton, of two inches, the division of which was very mi-

\* These camels, which serve for labor, and sometimes for food when salted, did not exist till the Béthencourts made the conquest of the Canaries. In the sixteenth century, asses were so abundant in the Isle of Fortaventure, that they became wild and were hunted. Several thousands were killed to save the harvest. The horses of Fortaventure are of singular beauty, and of the Barbary race. *Noticias de la historia general de las islas Canarias, par Don Jose de Viera, t. ii, p. 436.*

nute, without using a taper for the limb. Several of our fellow travellers were Canarians, who, like all other inhabitants of islands, vaunted with enthusiasm the beauty of their country. After midnight, great black clouds rising behind the volcano shrouded at intervals the moon and the beautiful constellation of the Scorpion. We beheld lights carried to and fro on shore, which were probably those of fishermen preparing for their labours. We had been employed, during our passage, in reading the ancient voyages of the Spaniards, and these moving lights recalled to our fancy those which Pedro Gutierrez, page of Queen Isabella, saw in the Isle of Guanahani, on that memorable night of the discovery of the New World.

On the 17th, in the morning, the horizon was foggy, and the sky slightly covered with vapours. The outlines of the mountain of Lanzerota appeared stronger; the humidity, increasing the transparency of the air, seemed at the same time to have brought the objects nearer our view. This phenomenon is well known to those, who have made hygrometrical observations in places whence the chain of the high Alps or the Andes is seen. We passed through the channel which divides the isle of Alegranza from Montana Clara, taking soundings the whole way. We examined the Archipelago of small islands situate to the north of Lanzerota, which are so



ill laid down in the chart of Mr. Fleurieu, though it is otherwise very exact, and in that which appeared in the voyage of the *Flora* frigate. The chart of the Atlantic Ocean, published in 1786 by order of M. de Castries, is equally erroneous in this point. The currents being extremely rapid in these latitudes, it is important for the safety of navigators to observe here, that the position of the five small islands, Alegranza, Clara, Graciosa, Roca del Este, and Infierno, are no where laid down with exactness, but in the chart of the Canaries by Mr. de Borda, and in the Atlas of Tofino, founded for this part on the observations of Don Jose Varela, which are nearly conformable to those of the *Boussole* frigate.

In the midst of this Archipelago, which is seldom traversed by vessels bound for Teneriffe, we were singularly struck with the configuration of the coasts. We thought ourselves transported to the Euganean mountains in the Vicentin, or the banks of the Rhine near Bonn \*. The form of organized beings varies according to the climate, and it is that extreme variety, which renders the study of the geography of plants and animals so attractive ; but the rocks, more ancient perhaps than the causes which have produced the difference of the climates on the globe, are the same in both hemispheres †. The por-

\* *Siebengebirge*, described by Mr. Nose.

† *Monum. Amer.* p. 122.

phyries containing vitreous feldspath and hornblende \*, the phonolite †, the greenstone, the amygdaloids, and the basalt have forms almost as invariable as simple crystallized substances. In the Canary islands, and in the mountains of Auvergne, in the Mittelgebirge in Bohemia, in Mexico, and on the banks of the Ganges, the formation of trapp is indicated by a symmetrical disposition of the mountains, by truncated cones, sometimes insulated, sometimes grouped ‡, and by elevated plains, both extremities of which are crowned by a conical rising.

The whole western part of Lanzerota, of which we had a near view, bears the appearance of a country recently overturned by volcanic eruptions. Every thing is black, parched, and stripped of vegetable mould. We distinguished, with our glasses, stratified basalt in thin and steeply sloping strata. Several hills resembled Monte Novo, near Naples, or those hillocks of scoria and ashes, which the opening earth threw up in a single night at the foot of the volcano of Jorullo, in Mexico. In fact, the Abbé Viera § relates, that in 1730 more than half the island changed its appearance. The *great volcano*, which we have just mentioned, and which the

\* *Amphibole* of Haüy.

† *Porphyrschiefer* of Werner.

‡ *Montigemelli*, *Zwillinsberge*.

§ Viera, t. ii. p. 404.

inhabitants call the volcano of *Temanfaya*, spread desolation over a most fertile and highly cultivated region; nine villages were entirely destroyed by the lavas. This catastrophe had been preceded by a tremendous earthquake, and for several years shocks equally violent were felt. This last phenomenon is so much the more singular, as it seldom happens at the end of an eruption, when the elastic vapours have found vent by the crater, after the ejection of the melted matter. The summit of the great volcano is a rounded hill, but not entirely conic. From the angles of altitude which I took at different distances, its absolute elevation did not appear to exceed three hundred toises. The neighbouring hills, and those of *Alegranza* and *Isla Clara*, were scarcely above one hundred or one hundred and twenty toises. We may be surprised at not finding these summits at a greater elevation, which seen at sea wear so majestic a form; but nothing is more uncertain than our judgment on the greatness of angles, which are subtended by objects close to the horizon. From illusions of this sort it arose, that before the measures\* of Messrs. de Churruca and Galleano, at Cape Pilar, navigators considered the mountains of the Straits of Magellan, and those of *Terra del Fuego*, as being extremely elevated.

\* Churruca, Apendice a la Relacion del Viaje al Magellanes, 1793, p. 76.

The island of Lanzerota bore formerly the name of *Titeroigotra*. On the arrival of the Spaniards, its inhabitants were distinguished from the other Canarians by marks of greater civilization. Their houses were built with free stone, while the Guanches of Teneriffe, like real troglodytes, dwelt in caverns. At Lanzerota, a very singular custom \* prevailed at that time, of which we find no example except among the people of Thibet. A woman had several husbands, who alternately enjoyed the prerogatives due to the head of a family. A husband was considered as such only during a lunar revolution, and whilst his rights were exercised by others, he remained classed among the household domestics. It must be regretted, that the missionaries who accompanied Jean de Béthencourt, and who sketched the history of the conquest of the Canaries, have given us no ampler details on the manners of a people who had such singular customs. In the fifteenth century, the island of Lanzerota contained two small distinct states, divided by a wall; a kind of monuments which outlive national enmities, and which we find in Scotland, in China, and Peru.

\* Viera, t. i, p. 150, 171, 191. Du Halde, Descrip. of China, t. iv, p. 461. In Thibet, polyandry is nevertheless much less common than is thought, and is blamed by the clergy. Hackman in Pallas, Neue Nordische Beiträge, B. 3, p. 282.

We were forced by the winds to pass between the islands of Alegranza and Montaña Clara ; and as none on board the sloop had sailed through this passage, we were obliged to be continually sounding. We found from twenty-five to thirty-two fathom. The lead brought up an organic substance of so singular a construction, that we were for a long time doubtful whether it was a zoophyte or a kind of seaweed. The drawing I made on the spot is engraved in the second volume of our *Equinoctial Plants* \*. The stem, of a brownish color and three inches long, has circular leaves that have lobes, and are indented at the edge. The colour of these leaves is a tender green, and they are membranous and streaked like those of the *adiantum*s and the *ginkgo biloba*. Their surface is covered with stiff and whitish hairs ; before their opening they are concave and enveloped one in the other. We observed no mark of spontaneous motion, no sign of irritability, not even on the application of galvanic electricity. The stem is not woody, but almost of a horny substance, like the stem of the *gorgons*. Azote and phosphorus having been abundantly found in several cryptogamous plants, an appeal to chemistry would be useless, to determine whether this organized substance belonged to the animal or vegetable kingdom.

\* *Equinox. Plants.* t. ii, p. 8, pl. 69.



It's great analogy to several sea plants, with adiantum leaves, especially with the genus caulerpa of Mr. Lamoureux, of which the fucus prolifer of Forskal is one of the numerous species, engaged us to rank it provisionally among the *sea-wracks*, and give it the name of fucus vitifolius. The bristles which cover this plant are found in several other fuci \*. The leaf, examined with a microscope at the instant we drew it up from the water, did not present, it is true, those *conglobate* glands, or those opaque points, which the parts of fructification in the genera of ulva and fucus contain; but how often do we find seaweeds in such a state, that we cannot yet distinguish any trace of seeds in their transparent parenchyma.

I should not have entered into these details, which belong to descriptive natural history, had not the vine-leaved fucus presented a physiological phenomenon of the greatest interest. Fixed to a piece of madrepora, this seaweed vegetates at the bottom of the ocean, at the depth of 192 feet, notwithstanding which, it's leaves were as green as those of our grasses. According to the experiments of Bouguer †, light is weakened

\* Fucus lycopodioides, and f. hirsutus.

† Traité d'optique, p. 256, 264, 346. The fucus vitifolius, at the depth of 32 fathoms, can have received a light only 203 times stronger than that of the moon, and consequently equal to half the light of a candle at a foot's distance. But after my direct experiments, the lepidium sativum scarcely takes

after a passage of 180 feet, in the ratio of 1 to 1477·8. The sea-weed of L'Alegranza consequently presents a new example of plants, which vegetate in a great obscurity without being whitened. Several germs, still enveloped in the bulbs of the lily tribes, the embryo of the malvaceæ, of the rhamnoides, of the pistacea, the viscum, and the citrus, the branches of some subterraneous plants ; in short, vegetables transported into mines, where the ambient air contains hydrogen, or a great quantity of azote, become green without light. From these facts, we are inclined to admit, that it is not only under the influence of the solar rays that this carburet of hydrogen is formed in the organs of plants, the presence of which makes the parenchyma appear of a lighter or darker green, according as the carbon predominates in the mixture \*.

Mr. Turner, who has so well made known the family of the seaweeds, and many other celebrated botanists, think that the greater part of the fuci which we gather on the surface of the ocean, and which from the 23d to the 35th degree of a tint of green by the vivid light of two lamps of Argand. See also Lambert, *Photometria*, p. 223.

\* These ideas are in part explained in my memoir on the phenomenon of *etiolation* (*Journal de Physique*, t. 40, p. 154) and in my *Aphorisms on the chemical physiology of Vegetables*, (*Flora Freibergensis*, p. 179). See also *Trans. of the Irish Academy*, vol. 8, p. 960.

latitude, and 32d of longitude, appear to the mariner like a vast inundated meadow, grow primitively at the bottom of the ocean, and float only in their ripened state, when they are torn off by the motion of the waves. If this opinion be founded, we must agree, that the family of seaweeds offers formidable difficulties to naturalists, who persist in thinking, that absence of light must always produce a whiteness; for how can we admit, that so many species of *ulvaceæ*, and *dictyoteæ*, with stems and green leaves, which float on the ocean, have vegetated on rocks almost at the surface of the water?

From some notions which the captain of the Pizarro had collected in an old Portuguese itinerary, he thought himself opposite a small fort, situate at the north of Teguisa, the capital of the island of Lanzerota. Mistaking a rock of basalt for a castle, he saluted it by hoisting the Spanish flag, and sent a boat with an officer to inquire of the commander if the English vessels were cruising in the roads. We were not a little surprised to learn, that the land, which we had considered as a prolongation of the coasts of Lanzerota, was the small island of Graciosa, and that for several leagues there was not an inhabited place.

We took advantage of the boat to survey the land, which enclosed a large bay. No language can express the emotion, which a naturalist feels, when he touches for the first time a land that is

not European. The attention is fixed on so great a number of objects, that he can scarcely define the impression he receives. At every step he thinks he discovers some new production; and in this tumultuous state of mind he does not recollect those which are most common in our botanical gardens, and collections of natural history. At two hundred yards from the coast, we saw a man fishing with a line. We steered towards him, but he took fright, and hid himself behind a rock. The sailors brought him back with difficulty. The sight of the sloop, the fire of the cannon in so solitary a place, though sometimes visited by Barbary corsairs, and the landing of the crew, had frightened this poor man. He informed us, that the small island of Graciosa, on which we had just landed, was separated from Lanzerota by a narrow channel called El Rio. He offered to conduct us to the port of Los Colorados, to get information respecting the blockade of Teneriffe, but as he assured us at the same time, that he had not seen any vessel for some weeks on the seas, the captain resolved to pursue his course to Santa Cruz.

The small part of the island of Graciosa, which we traversed, resembles those promontories of lava, which we see near Naples, between Portici and Torre del Greco. The rocks are naked, with no marks of vegetation, and scarcely any of ve-

getable soil. A few crustaceous lichen variolaria, lepraria, and urceolaria\* were scattered about upon the basalts. The lavas which are not covered with volcanic ashes remain for ages without any appearance of vegetation. On the African soil excessive heat, and lengthened drought, retard the growth of cryptogamous plants.

The basalts of Graciosa are not in columns, but divided into strata 10 or 15 inches thick. These strata are inclined under an angle of 80 degrees to the north-west. The compact basalt alternates with the strata of porous basalt and marl. The rock does not contain hornblende, but great crystals of foliated olivine, which have a triple *clivage* †. This substance is decomposed with great difficulty. Mr. Haüy considers it as a variety of the pyroxene. The porous basalt, which passes into *mandelstein*, has oblong cavities from two to eight lines diameter, lined with chalcedony, enclosing fragments of compact basalt. I did not remark that these cavities had the same direction,

\* We found the *lecidea astrovirens*, *urceolaria ocellata*, *u. diamarta*, (to which Mr. Achariur assimilates the lichen *koenigri* of my Flora of Friberg) *parmelia parietina*, *p. tenella*, (lichen *hispidus* Willd.) *p. atra*, *lecidia fusco-atra*, and many other species, which were hitherto thought to belong exclusively to the north of Europe. (Achar. Methodus Lichenum, t. i, p. 152.)

† Blättriger olivin.



or that the porous rock lay on compact strata, as happens in the currents of lava of *Ætna* and *Vesuvius*. The marl \*, which alternates more than a hundred times with the basalts, is yellowish, friable by decomposition, very coherent in the inside, and often divided into irregular prisms, analogous to the basaltic prisms. The sun discolours their surface, as it whitens several schists, by reviving a hydrocarburetted principle, which appears to be combined with the earth. The marl of *Graciosa* contains a great quantity of chalk, and strongly effervesces with nitric acid, even on points where it is found in contact with the basalt. This fact is so much more remarkable, as this substance does not fill the fissures of the rock, but it's strata are parallel to those of the basalt; whence we may conclude, that both fossils are of the same formation, and have a common origin. The phenomenon of a basaltic rock containing masses of indurated marl split into small columns, is also found in the *Mittelgebirge*, in *Bohemia*. Visiting those countries in 1792, in company with Mr. *Freiesleben* †, we even recognized in the marl of the *Stiefelberg* the imprint of a plant nearly resembling the *cerastium*, or the *alsine*. Are these strata, contained in the trappean mountains, owing to muddy irruptions? or must we consider them as sediments of water,

\* Mergel.

† *Bergmännisches Journal*, 1792, p. 215.

which alternate with volcanic depositions ? This last hypothesis seems so much the less admissible, since, from the researches of Sir James Hall on the influence of pressure in fusions, the existence of carbonic acid in substances contained in basalt offers nothing surprising. Several lavas of Vesuvius present similar phenomena. In Lombardy, between Vicenza and Abano, where the calcareous stone of the Jura \* contains great masses of basalt, I have seen this latter enter into effervescence with the acids wherever it touches the calcareous rock.

We had not time to reach the summit of a hill, that was very remarkable in having it's base formed of banks of clay under strata of basalt, like a mountain in Saxony †, which is become celebrated on account of the disputes of volcanic and neptunean geologists. These basalts were covered with a mammæform substance, which I vainly sought on the Peak of Teneriffe, and which is known by the name of volcanic glass, glass of Muller or Hyalite ; it is the transition from the opal to the calcedony. We struck off with difficulty some fine specimens, leaving masses that were eight or ten inches square untouched. I never saw in Europe such fine hyalites as I found in the island of Graciosa, and

\* Jura-kalstein.

† Scheibenberg huegel.

on the rock of porphyry called *el Peñol de los Bannos*, on the bank of the lake of Mexico.

Two kinds of sand cover the shore; one is black and basaltic, the other white and quartzose. In a place exposed to the rays of the sun, the first raised the thermometer to  $51\cdot 2^{\circ}$  ( $41^{\circ}$  R.) and the second to  $40^{\circ}$  ( $32^{\circ}$  R.) The temperature of the air in the shade was  $27\cdot 7^{\circ}$  or  $7\cdot 5^{\circ}$  higher than that of the air over the sea. The quartzose sand contains fragments of feldspath. It is thrown back by the water, and forms, in some sort, on the surface of the rocks, small islets where the seaweed vegetates. Fragments of granite have been observed at Teneriffe; the island of Gomora, from the details furnished me by Mr. Broussonet, contains a nucleus of micaceous schist\*; the quartz disseminated in the sand, which we found on the shore of Graciosa, is a different substance from the lavas, and the trappean porphyries which are so intimately connected with the volcanic productions. From these facts it seems evident, that in the Canary Islands, as well as on the Andes of Quito, in Auvergne, Greece, and the greater part of the globe, the subterraneous fires have pierced through the rocks of primitive formation. In treating hereafter of the great number of warm springs, which

\* Glimmerschiefer.

we have seen issuing from granite, gneiss, and micaceous schist, we shall have occasion to return to this subject, which is one of the most important of the physical history of the globe.

We reembarked at sunset, and hoisted sail, but the breeze was too feeble to permit us to continue our course to Teneriffe. The sea was calm ; a reddish vapor covered the horizon, and seemed to magnify every object. In this solitude, amidst so many uninhabited islets, we enjoyed for a long time the view of an austere and savage nature. The black mountains of Graciosa appeared like perpendicular walls of five or six hundred feet. Their shadows, thrown over the surface of the ocean, gave a gloomy aspect to the scenery. Rocks of basalt, emerged from the bosom of the water, wore the resemblance of the ruins of some vast edifice ; their existence carried our thoughts back to the remote period when submarine volcanoes gave birth to new islands, or rent the continents asunder. Every thing which surrounded us seemed to indicate destruction and sterility ; but the back ground of the picture, the coasts of Lanzerota, presented a more smiling aspect. In a narrow pass, between two hills, crowned with scattered tufts of trees, the marks of cultivation were visible. The last rays of the sun gilded the corn ready for the sickle. The desert even is animated wherever we can discover a trace of the industry of man.

We endeavoured to get out of this bay by the pass which separates Alegranza from Montana Clara, and through which we had easily entered, to land at the northern point of Graciosa. The wind having fallen, the currents drove us very near a rock, on which the sea broke with violence, and which is noted in the old charts under the name of Hell, or Infierno. As we examined this rock at the distance of two cables length, we found that it was a mass of lava three or four fathoms high, full of cavities, and covered with scoriæ resembling coke. We may presume that this rock \*, which modern charts call the West Rock (Roca del Oeste), was raised by volcanic fire ; and it might heretofore have been much higher ; for the *new island* of the Azores, which rose from the sea, at successive periods, in 1638 and 1719, had reached 354 feet † when it totally disappeared in 1723, to the depth of 480 feet. This opinion on the origin of the basaltic mass

\* Borda, Voyage de la Flore, vol. i, p. 336. Bory St. Vincent, Essai sur les Isles Fortunées, p. 20. I must here observe, that this rock is already noted on the celebrated venetian chart of Andrea Bianco, but that the name of *Infierno* is given, as in the most ancient chart of Picigano, made in 1367, to Teneriffe, without doubt because the Guanches considered the peak as the entrance into Hell. In the same latitudes an island made it's reappearance in 1811.

† In 1720, this island was visible at seven or eight leagues distance. Mem. de l'Académie, 1722, p. 12. Fleurieu, Voyage de l'Isis, vol. i, p. 565.



of the *Infierno* is confirmed by a phenomenon, which was observed towards the middle of the last century in these same latitudes. At the time of the irruption of the volcano of *Temanfaya*, two pyramidal hills of lithoid lava rose from the bottom of the ocean, and united themselves by degrees to the island of *Lanzerota*.

As we were prevented by the fall of the wind, and by the currents, from repassing the channel of *Alegranza*, we resolved on tacking during the night between the isle *Clara* and the *West Rock*. This resolution had nearly proved fatal. A calm is very dangerous near this last rock, towards which the current drives with considerable force. We began to feel the effects of this current at midnight. The proximity of the stony masses, which rise perpendicularly above the water, deprived us of the little wind which blew : the sloop no longer obeyed the helm, and we dreaded striking every instant. It is difficult to conceive how a mass of basalt, insulated in the vast expanse of the ocean, can cause so considerable a motion in the waters. These phenomena, well worthy the attention of naturalists, are nevertheless well known to mariners ; they are extremely to be dreaded in the *Pacific Ocean*, particularly in the small *Archipelago* of the islands of *Gallipagos*. The difference of temperature which exists between the fluid and the mass of rocks cannot explain the direction which these currents

take; and how can we admit, that the water is engulfed at the base of these rocks, which often are not of volcanic origin; and that this continual engulfing determines the particles of water to fill up the vacuum that takes place \*?

The wind having freshened a little towards the morning on the 18th, we succeeded in passing the channel. We drew very near the Infierno the second time, and remarked the large crevices, through which the gaseous fluids probably issued, when this basaltic mass was raised. We lost sight of the small islands of Alegranza, Montana Clara, and Graciosa, which appear to have never been inhabited by the Guanches. They are now visited only to gather archil; this production is however less sought after, since so many other lichens of the north of Europe yield other materials proper for dyeing. Montana Clara is noted for its beautiful Canary birds. The note of these birds varies with their flocks, like that of our chaffinches, which often differs in two neighbouring districts. Montana Clara yields pasture for goats, which proves that the interior of this islet is less arid than its coasts. The name of Ale-

\* We are surprised to read in a highly useful work, which is in the hand of every seaman, in the ninth edition of Hamilton Moore's Practical Navigator, p. 200, that it is by the effect of the attraction of the masses, or of universal gravitation, that a vessel leaves the coasts with difficulty, and that the boat of a frigate is attracted by the frigate itself.

granza is synonymous with the Joyous\*, which was given it by the first conquerors of the Canary Islands, two Norman barons, Jean de Béthencourt, and Gadifer de Salle. This was the first point on which they landed. After remaining several days at Graciosa, a small part of which we examined, they conceived the project of taking possession of the neighbouring isle of Lanzerota, where they were welcomed by Guadarfia, sovereign of the Guanches, with the same hospitality that Cortez found in the palace of Montezuma. The shepherd king, who had no other riches than his goats, became the victim of coward treachery, like the sultan of Mexico.

We sailed along the coasts of Lanzerota, of the island of Losbos, and of Fortaventura. The second of these islands seems to have anciently formed part of the two others. This geological hypothesis was started in the seventeenth century by a Franciscan, Juan Galindo. This writer even supposed that, the king, Juba, had named six Canary Islands only, because, in his time, three among them were contiguous. Without admitting the small probability of this hypothesis, learned geographers have seemed to recognize, in the Archipelago of the Canaries, the two isles

\* La Joyeuse.

Junoniæ, Nivaria, Ombrios, Canaria, and the Capraria of the ancients \*.

The haziness of the horizon prevented us, during the whole of our passage from Lanzerota to Teneriffe from discovering the summit of the peak of Teyde. If the height of this volcano is 1905 toises, as the last trigonometrical measure of Borda indicates, it's summit ought to be visible at a distance of 43 leagues, supposing the eye on a level with the ocean, and a refraction equal to 0.079, of distance. It has been doubted † whether the peak has ever been seen from the channel, which separates Lanzerota from Fortaventura, and which is distant from the volcano, according to the chart of Varela,  $2^{\circ} 29'$ , or nearly 50 leagues. This phenomenon appears nevertheless to have been verified by several officers of the Spanish royal marine. I had in my hand, on board the Pizarro, a journal, in which it was noted, that the peak of Teneriffe had been seen at 135 miles distance, near the southern cape of Lanzerota, called Pichiguera. It's summit was discovered under an angle considerable enough to lead the observer, Don Manuel Baruti, to think that the volcano might have been visible

\* Gosselin, Rech. sur la Géog. des Anciens, t. i, p. 146, 156, 163.

† Voyage de la Flore, t. i, p. 380. My chronometer gave me, on the coast north-west of Lanzerota,  $15^{\circ} 52' 10''$  west of the meridian of Paris.

at nine miles farther. It was in September, towards the evening, and in very damp weather. Reckoning fifteen feet for the elevation of the eye, I find, that to render an account of this phenomenon, we must suppose a refraction equal to 0·158 of the arch, which is not very extraordinary for the temperate zone. According to the observations of General Roy, the refractions vary in England from one twentieth to one third ; and if it be true, that they reach these extreme limits on the coast of Africa, which I much doubt, the peak, in certain circumstances, may be seen on the deck of a vessel as far off as 61 leagues.

Navigators who have much frequented these latitudes, and who can reflect on the physical causes of the phenomena, are surprised that the peaks of Teyde and of the Azores\* are sometimes visible at a very great distance, though at other

\* The height of this peak, according to Fleurieu, is 1100 toises ; to Ferrer, 1238 toises ; and to Tofino, 1260 toises : but these measures are only approximative estimations. The captain of the Pizarro, Don Manuel Cagigal, proved to me, by his journal, that he observed the peak of the Azores at the distance of 37 leagues, when he was sure of his latitude within two minutes. The volcano was seen at S. 4° E., so that the error in longitude must have an almost imperceptible influence in the estimation of the distance. Nevertheless, the angle which the peak of the Azores subtended was so great, that Mr. Cagigal thinks this volcano must be visible at more than 40 or 42 leagues. The distance of 37 leagues supposes an elevation of 1431 toises.



times they are not seen when the distance is much less, and the sky appears serene and the horizon free from fogs. These circumstances are so much the more worthy the attention of naturalists, as several vessels returning to Europe wait impatiently for a sight of these mountains, to rectify their longitude, and think themselves much farther off than they really are, when in fine weather these peaks are not perceptible at distances where the angles subtended ought to be very considerable. The constitution of the atmosphere has a great influence on the visibility of distant objects. It may be admitted in general, that the Peak of Teneriffe is seldom seen at a great distance, in the warm and dry months of July and August, and that on the contrary it is seen at very extraordinary distances in the months of January and February, when the sky is slightly covered, and immediately after a heavy rain, or a few hours before it falls. It appears, that the transparency of the air is prodigiously increased, as we have already observed, when a certain quantity of water is uniformly diffused through the atmosphere. Independent of these observations, it is not astonishing, that the peak of Teyde should be seldomer visible at a very remote distance, than the summits of the Andes, which were so long under my observations. This peak, inferior in height to those parts of the chain of Mount Atlas, at the foot of which is the city of

Morocco, is not, like those points \* covered with perpetual snows. The *Piton*, or *Sugar Loaf*, which terminates the peak, no doubt reflects a great quantity of light, on account of the whitish colour of the punice stone thrown up by the crater ; but the height of this little truncated cone does not form a twenty-secondth part of the total elevation. The flanks of the volcano are covered either with blocks of black and scorified lava, or with a luxuriant vegetation, the masses of which reflect so much the less light, as the leaves of the trees are separated from each other by shadows of more considerable extent than that of the part which is enlightened.

Hence it results, that setting aside the *Piton*, the peak of Teyde is in the class of those mountains, which, according to the expression of Bouguer, are seen at considerable distances only in a *negative manner*, because they intercept the light which is transmitted to us from the extreme limits of the atmosphere; and that we perceive their existence only on account of the difference of intensity, which subsists between the aerial light which surrounds them, and that which is reflected by the particles of air placed between the mountains and the eye of the observer †. As we with-

\* According to Haest, and Jackson, Account of the Empire of Morocco, p. 43.

† *Traité d'Optique*, p. 365. It follows from the experiments of the same author, in order that this difference may

draw from the isle of Teneriffe, the *Piton* or *Sugar Loaf* is seen for a long time in a *positive manner*, because it reflects a whitish light, and clearly detaches itself from the sky; but as this cone is only 80 toises high, by 40 in breadth at it's summit, it has recently been a question\*, whether from the diminutiveness of it's mass it can be visible at distances which exceed 40 leagues; and if it be not rather probable, that navigators distinguish the peak as a small cloud above the horizon, only when the base of the Piton begins to be *visible* on it. If we admit, that the mean breadth of the Sugar Loaf is 100 toises, we find that the little cone, at 40 leagues distance, still subtends, in the horizontal direction, an angle of more than three minutes. This angle is considerable enough to render an object visible; and if the height of the Piton greatly exceeded it's basis, the angle in the horizontal direction might be still smaller, and the object still continue to make an impression on our organs; for micrometrical observations have proved, that the limit of vision is but a minute only, when the dimensions of the objects are the same in every direction. We distinguish at a distance, by the eye only, trunks of trees insulated in a vast plain, though become perceptible to our organs, and the mountain detach itself distinctly from the sky, that one of these lights should be a sixtieth part stronger than the other.

\* Marchand. t. 2, p. 10.

the subtended angle be under twenty-five seconds.

As the visibility of an object, which detaches itself in a brown color, depends on the quantities of light which the eye meets with on two lines, one of which ends at the mountain, and the other reaches on to the surface of the aerial ocean, it follows that the farther we remove from an object, the smaller the difference becomes between the light of the surrounding atmosphere, and that of the strata of air placed before the mountain. It is on this account, that, when less elevated summits begin to appear above the horizon, they present themselves at first under a darker tint, than those we discover at very great distances. In the same manner, the visibility of the mountains, which are seen only in a negative manner, does not depend solely on the state of the lower regions of the air, to which our meteorological observations are limited, but also on it's transparency and physical constitution in the most elevated parts ; for the image detaches itself better in proportion as the aerial light, which comes from the limits of the atmosphere, has been originally more intense, or rather has undergone less loss in it's passage. This consideration explains to a certain point, why, under a perfectly serene sky, the state of the thermometer and the hygrometer, being precisely the same in the air which is nearest the Earth, the peak is sometimes



visible, and at other times invisible, to navigators at equal distances. It is even probable, that the chance of perceiving this volcano would not be greater, if the ashy cone, at the summit of which is the mouth of the crater, were equal, as in Vesuvius, to a quarter of the total height. These ashes, which are pumice stone crumbled into dust, do not reflect as much light as the snow of the Andes ; are the cause why the mountain, seen from afar, without detaching itself in a bright, detaches itself more feebly in a brown color ; and contribute, if we may use the expression, to equalize the portions of aerial light, the variable difference of which renders the object more or less distinctly visible. Calcareous mountains, stripped of vegetable earth, summits covered with granitic sand, the high savannahs of the Cordilleras\*, which are of a golden yellow, are undoubtedly distinguished at small distances better than objects which are seen in a negative manner ; but the theory indicates a certain limit, beyond which these last detach themselves more distinctly from the azure vault of the sky.

The colossal summits of Quito and Peru, towering above the limit of the perpetual snows, concentré all the advantages, which render them visible under very small angles. We have stat-

\* *Los Pajonales*, from *paja*, straw. It is the name of the region of the *gramina*, which encircles the zone of the perennial snows. *Géogr. vég.* p. 70.



ed, that the circular summit of the peak of Teneriffe is only a hundred toises in diameter. According to the measures I made at Riobamba, in 1803, the dome of the Chimborazo, 153 toises below it's summit, consequently in a point which is 1300 toises higher than the peak, is still 673 toises (1312 metres) in breadth. The zone of perennial snows also forms a fourth of the height of the mountain ; and the base of this zone, seen on the coast of the Southern Ocean, fills an extent of 3437 toises (6700 metres). But though Chimborazo is two thirds higher than the peak, we do not see it, on account of the curve of the globe, at more than 38 miles and a third farther\*. The radiant brilliancy of it's snows, when at the port of Guayaquil, at the end of the rainy season, it is discovered at the horizon, may lead us to suppose, that it must be seen at a very great distance in the South Sea. Pilots highly worthy of credit have assured me, that they have seen it from the rock of Muerto, to the south-west of the isle of Puna, at a distance of 47 leagues†. When-

\* Without attending to the refraction, the Peak of Teneriffe (1904 toises) is visible at  $1^{\circ} 57' 22''$ , Mount Blanc (2440 toises) at  $2^{\circ} 13' 0''$ , and Chimborazo (3350 toises) at  $2^{\circ} 35' 30''$ . The mean refraction, supposed to be 0.08, augments this distance, as to Chimborazo, only fourteen miles.

† According to the charts of the *Deposito hydrografico* of Madrid. Admitting  $1^{\circ} 13' 32''$  for the difference of the meridians of Guayaquil and Quito, such as I found it (*Observ.*

ever it has been seen at a greater distance, the observers, uncertain of their longitude, have not been in a situation to furnish precise data.

The aerial light, projected on the mountains, increases the visibility of those which are seen positively ; it's energy diminishes, on the contrary, the visibility of the objects, which, like the peak of Teneriffe and that of the Azores, detach themselves in a brown tint. Bouguer, building on theoretical considerations, found that according to the constitution of our atmosphere, the mountains seen negatively cannot be perceived at distances which exceed 35 leagues\*. It is important here to observe, that these calculations are contrary to experience. The peak of Teneriffe has been often seen at 36, 38, and even at 40 leagues. Moreover, in the vicinity of the Sandwich Islands, the summit of Mowna

*Ast.* t. ii, p. 298, 357, and 433) the Muerto is a little less distant than Chimborazo.

\* If, according to the theory of Bouguer, (*Traité d'Optique* p. 360) the intensity of the aerial colour, which is reflected by the whole of the atmosphere towards the horizon in a determinate direction, is equal to  $\frac{2375}{10000}$  q. ; the intensity, after a passage of 30 leagues, would be  $\frac{2525}{10000}$  q. This quantity differs from the other a little more than one sixtieth, whilst after a passage of 45 leagues, the intensity of the aerial colour is already  $\frac{2565}{10000}$  q., which differs too little from  $\frac{2575}{10000}$  q. for the difference to be perceived by our organs. From these data we find by interpolation, that the visibility should have ceased at 35 leagues distance.

Roa\*, at a season when it was without snows, was seen on the skirt of the horizon, at the distance of 53 leagues. This is the most striking example we have hitherto known of the visibility of a mountain ; and what is the more remarkable, it is an object seen negatively which furnishes the example.

I thought it proper to bring together these considerations at the end of this chapter, because in treating so closely on one of the most important problems of optics, that of the diminution

\* The height of Mowna Roa, according to Marchand, is more than 2598 toises ; according to King, it is 2577 toises ; but these measures, notwithstanding their accidental concordance, are not founded on very exact measurements. It is a very extraordinary phenomenon, to see a summit placed in the 19th degree of latitude, and which is probably 2500 toises high, entirely stripped of it's snows. The very flattened form of Mowna Roa, the *Mesa* of the old Spanish charts, it's insulated situation in the midst of the ocean, and the frequency of certain winds, which, modified by the ascending current, blow obliquely, may be the principal causes. It is difficult to believe, that captain Marchand was much deceived in the estimation of the distance at which he saw, on the 10th of October 1791, the summit of Mowna Roa. He had left the island of Owhyhee only the 7th in the evening ; and from the movement of the waters, and the lunar observations of the 19th, it is probable that the distance was even greater than 53 leagues. Besides, an experienced navigator, Mr. Fleuriu, relates, that at a distance of 35 or 36 leagues the peak of Teneriffe is visible, even in weather that is not perfectly clear. *Voy. de Marchand*, vol. i, p. 408 and 427 ; vol. ii, p. 10 and 78.

of light in its passage across the strata of the atmosphere, they may be at the same time of some practical utility. The volcanoes of Teneriffe, and of the Azores, the Sierra Nevada of St. Martha, the peak of Orizaba, the Silla of Caracas, Mowna Roa, and Mount St. Elias, insulated in the vast extent of the seas, or placed on the coasts of continents, serve as sea marks to direct the pilot, who is deprived of the means fitted to determine the position of the vessel by the observation of the stars ; every thing, which has a relation to the visibility of these natural sea marks, is interesting to the safety of navigation.

## CHAPTER II.

*Stay at Teneriffe.—Journey from Santa Cruz to Orotava.—Excursion to the top of the Peak of Teyde.*

FROM the time of our departure from Graciosa, the horizon continued so hazy, that notwithstanding the considerable height of the mountains of Canary\*, we did not discover this island till the evening of the 18th of June. It is the granary of the archipelago of the Fortunate islands, and what is very remarkable in a region situate beyond the limits of the tropics, we were assured, that in some districts, there are two wheat harvests in the year; one in February, and the other in June†. Canary has never been visited by a learned mineralogist; yet this island is so much the more worthy of observation, as the physiognomy of its mountains, disposed in parallel chains, appeared to me to differ entirely from that of the summits of Lanzerota and Te-

\* Isla de la Gran Canaria.

† Ledra, Voyage à Teneriffe, t. i, p. 37.



neriffe. Nothing is more interesting for the geologist, than to observe the relations, on the same point of the globe, between volcanic countries, and those which are primitive or secondary. When the Canary islands shall have been some day examined in all the parts, which compose the system of these mountains, we shall find, that we have been too precipitate in considering the whole group as raised by the action of submarine fires.

The 19th, in the morning, we discovered the point of Naga\*, but the Peak of Teneriffe was still invisible: the land, obscured by a thick fog, presented forms that were vague and confused. As we approached the road of Santa Cruz, we observed that these vapours, driven by the winds, drew nearer. The sea was strongly agitated, as it most commonly is in those latitudes. We anchored after several soundings, for the mist was so thick, that we could scarcely distinguish objects at a few cables' distance; but at the moment we began to salute the place, the fog was instantly dispelled. The peak of Teyde appeared in a break above the clouds, and the first rays of the sun, which had not yet risen on us, illuminated the summit of the volcano. We hastened toward the bow of the vessel, to enjoy the magnificent spectacle, when at the same instant we

\* *Punta de Naga, Anaga, or Nago.*

saw four English ships of the royal navy lying to, very near the poop. We had passed without being perceived; and the same mist which had hidden the peak from our view, had saved us from the danger of being carried back to Europe. It would have been very painful to naturalists, to have seen the coast of Teneriffe, without having been able to tread a soil torn up by volcanoes.

We immediately got up our anchor, and the Pizarro stood in as close as possible to the fort, to be under it's protection. It was on this shore, that, in the landing attempted by the English two years before our arrival\*, admiral Nelson had his arm carried off by a cannon ball. The governor general of the Canaries† sent an order to the captain of the sloop, to put on shore the dispatches from the court for the governors of the colonies, the money on board, and the public correspondence. The English vessels left the road, having given chase the evening before to the packet boat the *Alcudia*, which had left Corunna a few days before us. She was obliged to touch at the port of Palmas, in the isle of Canary, and several passengers, who were going in a boat to Santa Cruz, had been made prisoners.

The situation of this town is very similar to that of La Guayra, the most frequented port of

\* In the month of July, 1797.

† Don Andrea de Perlasca.

the province of Caraccas. The heat is excessive in both places, and from the same causes ; but the aspect of Santa Cruz is more gloomy. On a narrow and sandy beach, houses of dazzling whiteness, with flat roofs, and windows without glass, are stuck against a wall of black perpendicular rocks, stripped of vegetation. A fine mole, built of freestone, and the public walk planted with poplars, are the only objects, which break the sameness of the landscape. The view of the peak, such as it presents itself above Santa Cruz, is much less picturesque than that we enjoy from the port of Orotava. There, a highly cultured and smiling plain offers a pleasing contrast with the wild aspect of the volcano. From the groups of palm trees and bananas, which line the coast to the region of the arbutus, the laurel, and the pine, the volcanic rock is crowned with luxuriant vegetation. We easily conceive how the inhabitants, even of the beautiful climates of Greece and Italy, fancied that they recognised one of the Fortunate Isles in the western part of Teneriffe. The eastern side, that of Santa Cruz, on the contrary, is every where struck with the marks of sterility. The summit of the peak is not more arid than the promontory of basaltic lavas, which stretches towards the point of Naga, and on which succulent plants, springing up in the clefts of the rocks, scarcely indicate a preparation of soil. At the port of Oro-

tava, the top of the Piton subtends an angle in height of more than eleven degrees and a half: whilst at the mole of Santa Cruz\* this angle scarcely exceeds  $4^{\circ} 36'$ .

Notwithstanding this difference, and though in the latter place the volcano rises above the horizon scarcely as much as Vesuvius seen from the mole of Naples, the aspect of the peak is still very majestic, when those who anchor in the road discover it for the first time. The Piton alone was visible to us; its cone projected itself on a sky of the purest blue, whilst dark thick clouds enveloped the rest of the mountain to the height of 1800 toises. The pumice stone, illumined by the first rays of the sun, reflected a reddish light, like that which paints the summits of the higher Alps. This light by degrees becomes a dazzling whiteness; and, deceived like the greater part of travellers, we thought that the peak was still covered with snows, and that we should with difficulty reach the edge of the crater.

We have remarked, in the Cordilleras of the Andes, that the conical mountains, such as Cotopaxi and Tungurahua, are oftener seen free from clouds, than those mountains, the tops of which are broken into bristly points, like Antisana and Pichincha; but the peak of Teneriffe,

\* The oblique distance from the top of the volcano to Orotava and to Santa Cruz are nearly 3600 toises and 22500 toises.



notwithstanding it's pyramidical form, is a great part of the year enveloped in vapours, and is sometimes, during several weeks, invisible from the road of Santa Cruz. It's position to the west of an immense continent, and it's insulated situation in the midst of the seas, are no doubt the causes of this phenomenon. Navigators are well apprised, that the smallest islets, those which are without mountains, collect and harbour the clouds. The decrement of heat is also different above the plains of Africa, and above the surface of the ocean\* ; and the strata of air, brought by the trade winds, cool in proportion as they advance towards the west. If the air has been extremely dry above the burning sands of the desert ; it is very quickly saturated when it has entered into contact with the surface of the sea, or with the air that lies on this surface. It is easy to conceive, therefore, why the vapours become visible in the atmospherical strata, which, at a distance from the continent, have no longer the same temperature as when they began to be saturated with water. The considerable mass of a mountain, which rises in the midst of the Atlantic, is also an obstacle to the clouds, which are driven out to sea by the winds.

We waited long and impatiently the permission of the governor of the place to land. I employed this time in making the necessary ob-

\* Obs. Ast. t. i, p. 126.



servations for determining the longitude of the mole of Santa Cruz, and the dip of the needle. Berthoud's chronometer gave, for the first  $18^{\circ} 33' 10''$ . This differs three or four minutes from the result of former observations by Fleurieu, Pingré, Borda, Vancouver, and La Peyrouse. Mr. Quenot nevertheless obtained  $18^{\circ} 33' 36''$ , and the unfortunate Captain Bligh  $18^{\circ} 34' 20''$ . The precision of my result was confirmed three years after, on the voyage of the chevalier Krusenstern, who found Santa Cruz  $16^{\circ} 12' 45''$  west of Greenwich, and consequently  $18^{\circ} 33' 0''$  west of Paris. The data prove, that the longitudes Captain Cook assigned to Teneriffe and the Cape of Good Hope are much too far west\*. The same navigator had found the magnetic dip, in 1799,  $61^{\circ} 52'$ . Mr. Bonpland and myself observed it at  $62^{\circ} 24'$ , a result conformable to that which was obtained in 1791 by Mr. de Rossel in the voyage of D'Entrecasteaux†. The variation of the needle differs several degrees, according to the place where the observation is made, at the Mole, or at several points to the north, along the shore. We must not be surprised at these variations in a place surrounded by volcanic rocks. I remarked with Mr. Gay-Lussac, that

\* Galeano. Viage ad Magellanes, p. 8. Krusenstern, Reise um die Welt, th. i. s. 78: and my Obs. Astron. t. i, p. xxxvii, 27, and 33.

† Voyage à la Recherche de la Peyrouse, t. ii, p. 291.

on the declivity of Vesuvius, and in the inside of its crater, the intensity of the magnetic forces is modified by the proximity of the lavas\*.

After having undergone the fatigue of answering the numberless questions about political events put by persons who came to visit us on board, we landed. The boat was immediately sent back to the ship, lest the surf, which in this road is very dangerous, should drive it against the mole. The first object that met our view was a tall woman, of a very tawny complexion, and badly clothed, who was called the *capitana*. She was followed by several others, whose dress was not more becoming. They all earnestly requested permission to go on board the Pizarro, which was of course refused. In this port, so much frequented by Europeans, licentiousness bears the semblance of order. The *capitana* is a chief chosen by her companions, over whom she exercises great authority. She prevents whatever may be injurious to the service of the vessels; she engages the sailors to return on board at their stated hours. It is to her that the officers apply, when they fear that any of their crew conceal themselves with the intention of deserting.

On entering the streets of Santa Cruz, we felt a suffocating heat, though the thermometer was not above 25 degrees. Those who have for a

\* Mémoires de la Société d'Arcueil, t. i, p. 9.

long time breathed the air of the sea suffer every time they land ; not because this air contains more oxygen than the air on shore, as has been erroneously stated, but because it is less charged with those gaseous combinations\*, which the animal and vegetable substances, and the mud resulting from their decomposition, pour into the atmosphere. Miasms that escape chemical analysis have a powerful effect on our organs, especially when these have not undergone for a long while the same kind of irritation.

Santa Cruz, the Annaza of the Guanches, is a neat town, with a population of 8000 souls. I was not struck with the excessive number of monks and secular ecclesiastics, which travellers have thought themselves under the necessity of finding in every country under the Spanish government ; nor shall I stop to enter into the description of the churches ; the library of the Dominicans, which contains scarcely a few hundred volumes ; the mole, where the inhabitants assemble to inhale the freshness of the evening breeze ; or the famed monument of marble of Carara, thirty feet high, dedicated to *our Lady of the Candelaria*, in memory of her miraculous appearance, in 1392, at Chimisay, near Guimar. The port of Santa Cruz may be considered as a great caravansary, on the road to America and the Indies. Every traveller, who writes the nar-

\* Nouv. Espag. t. ii, p. 787.

rative of his adventures, begins by a description of Madeira and Teneriffe ; and if in the natural history of these islands there yet remains as it were, an immense field untrod, we must admit, that the topography of the little towns of Funchal, Santa Cruz, Laguna, and Orotava, leaves scarcely any thing untold\*.

The recommendation of the court of Madrid procured us in the Canaries, as in all the other Spanish possessions, the most satisfactory reception. The captain general gave us immediate permission to examine the island. Col. Armiaga, who commanded a regiment of infantry, received us into his house with a kind hospitality. We could not cease admiring the banana, the papaw tree, the poinciana pulcherrima, and other plants, which we had hitherto seen only in hot houses, cultivated in his garden in the open air. The climate of the Canaries however is not warm enough to ripen the real *platano arton*, with triangular fruit from seven to eight inches long, and which, requiring a temperature of 24 centesimal degrees, does not flourish, even in the Valley of Caraccas. The bananas of Teneriffe

\* Borda, Voy. de la Flore, t. i, p. 86. Vieyra, Noticias historicas, t. ii, p. 134. Bory de St. Vincent, Essai sur les Isles Fortunées, p. 230. Ledru, Voyage aux Isles de Ténériffe et de Porto Rico, t. i, p. 37. Milbert, Voy. pitt. à l'Isle de France, t. i, p. 9. Lord Macartney's Voyage, vol. i, p. 74.



are those named by the Spanish planters *camburis* or *guineos*, and *dominicos*. The *camburi*, which suffers the least from the cold, is even cultivated with success at Malaga\*; but the fruit which we see occasionally at Cadiz comes from the Canary islands by vessels, which make the passage in three or four days. In general, the *musa*, known by every people under the torrid zone, though hitherto never found in a wild state, has as great a variety of fruit as our apple and pear trees. These varieties †, which are confounded by the greater part of botanists, though they require a very different climate, are become permanent by long cultivation.

We went to herbalize in the evening towards the fort of Passo Alto, along the basaltic rocks that close the promontory of Naga. We were very little satisfied with our harvest, for the drought and dust had almost destroyed vegetation. The *cacalia kleinia*, the *euphorbia canariensis*, and several other succulent plants, which draw their nourishment from the air rather than the soil on which they grow, reminded us by their appearance, that this group of islands belongs to Africa, and even to the most arid part of that continent.

Though the captain of the ship had orders to stop long enough at Teneriffe, to give us time

\* The mean temperature of this town is only 18°.

† *Nouv. Esp. t. ii, p. 362.*



to scale the summit of the peak, if the snows did not prevent our ascent, we received notice, on account of the blockade of the English ships, not to hope a longer delay than that of four or five days. We consequently hastened our departure for the port of Orotava, which is situate on the western declivity of the volcano, where we were sure of finding guides. I could find no one at Santa Cruz, who had mounted the peak, and I was not surprised at this. The most curious objects become less interesting, in proportion as they are placed nearer to us; and I have known inhabitants of Schaffhausen, in Switzerland, who had never seen the fall of the Rhine but at a distance.

The 20th of June, before sunrise, we began our excursion by ascending to the Villa de Laguna, elevated 350 toises\* above the port of Santa Cruz. We could not verify this estimation of the height, the surf not having permitted us to return on board during the night, to take our barometers and dipping needle. As we foresaw, that our expedition to the Peak would be very precipitate, we consoled ourselves easily with the idea of not exposing instruments, which were to serve us in countries less known by Europeans. The road by which we ascended to Laguna is on the right of a torrent, or *baranco*, which in the

\* This estimation is but an approximation. See the note at the end of the third chapter.

rainy season forms fine cascades ; it is narrow and tortuous. I have been assured since my return, that Mr. de Perlasca has laid out a new road, which will admit carriages. Near the town we met some white camels, which seemed to be very slightly laden. The chief employment of these animals is to transport merchandise from the customhouse to the warehouses of the merchants. They are generally laden with two chests of Havanna sugar, which together weigh 900 pounds ; but this load may be augmented to thirteen hundred weight, or 52 arrobas of Castile. Camels are not plenty at Teneriffe ; while they exist by thousands in the two isles of Lanzerota and Fortaventura ; the climate and vegetation of these islands, placed nearer Africa, are more analogous to those of that continent. It is very extraordinary, that this useful animal, which breeds in South America, should be almost barren at Teneriffe. In the fertile district of Adexe only, where the plantations of the sugar cane are most considerable\*, camels have sometimes been known to breed. These beasts of burden, as well as horses, were brought into the Canary islands in the fifteenth century by the Norman conquerors. The Guanches were unacquainted with them ; and this fact seems to be very well accounted for by the difficulty of transporting

\* They do not at present produce yearly above 300 quintals of moist sugar.

an animal of such bulk in frail canoes, without recurring to the necessity of considering the Guanches as a remnant of the people of the Atlantis, or a different race from that of the western Africans.

The hill, on which the town of San Christobal de la Laguna is built, belongs to the system of basaltic mountains, which, independent of the system of less ancient volcanic rocks, form a broad girdle around the peak of Teneriffe. The basalt on which we walked was of a darkish brown, compact, half decomposed, and exhaled, when breathed on, a clayey smell. We discovered hornblende, olivine \*, and translucent pyroxenes † with a perfectly lamellar fracture, of a tender olive green, and often crystallized in prisms of six planes. The first of these substances is extremely rare at Teneriffe ; and I never found it in the lavas of Vesuvius ; those of Etna alone contain it in abundance. Notwithstanding the great number of blocks, which we stopped to break, to the great regret of our guides, we could discover neither nepheline, nor leucite ‡, nor feldspath. This, which is so common in the basaltic lavas of the island of Ischia, does not begin to appear at Teneriffe, till we approach the volcano. The rock of Laguna is not columnar,

\* Peridot granuliforme. Haüy.

† Augit. Werner.

‡ Amphigène. Haüy.

but divided into ledges of small thickness, and inclined to the east under an angle of 30 or 40 degrees. It has no where the appearance of a current of lava flowing from the sides of the peak. If the present volcano has given birth to these basalts, we must suppose, that, like the substances which compose the Somma, at the back of Vesuvius, they are the effect of a submarine effusion, in which the liquid mass has formed real strata. A few bushy euphorbiums, the *cacalia kleinia*, and Indian figs (cactus), which are become wild in the Canary islands, as well as in the south of Europe and the whole continent of Africa, are the only plants we see on these arid rocks. The feet of our mules were slipping every moment on beds of stone, which were very steep. We nevertheless recognized the remains of an ancient pavement. In these colonies we discover at every step some traces of that activity, which the Spanish nation displayed in the 16th century.

As we approached Laguna, we felt the temperature of the atmosphere gradually decrease. This sensation is so much the more agreeable, as the air of Santa Cruz is very suffocating. As our organs are more affected by disagreeable impressions, the change of temperature becomes still more sensible when we return from Laguna to the port : we seem then to be drawing near the mouth of a furnace. The same impression is felt,



when, on the coast of Caraccas, we descend from the mountain of Avila to the port of La Guayra. According to the law of the decrement of heat, three hundred toises in height produce in this latitude only three or four degrees difference in temperature. The heat which overpowers the traveller on his entrance into Santa Cruz, or La Guayra, ought consequently to be attributed to the reverberation from the rocks, against which these towns are built.

The perpetual coolness, which is found at Laguna, is the reason why in the Canaries it is considered as a delightful abode. Situate in a small plain, surrounded by gardens, protected by a hill which is crowned by a wood of laurels, myrtle, and arbutus, the capital of Teneriffe is very beautifully placed. We should be mistaken, if, according to the account of some travellers, we believed it seated on the border of a lake. The rain sometimes forms a sheet of water of some extent; and the geologist, who beholds in every thing the past rather than the present state of nature, can have no doubt, but that the whole plain is a great basin dried up. Laguna, fallen from its opulence, since the lateral eruptions of the volcano have destroyed the port of Garachico, and Santa Cruz has become the centre of the commerce of this island, contains only 9000 inhabitants, of whom nearly 400 are monks, divided among six convents. Some travellers have asserted,



that half the population wore the ecclesiastic dress. The town is surrounded with a great number of windmills, which indicate the cultivation of wheat in these high countries. I shall observe on this occasion, that different kinds of grain were known to the Guanches. They called wheat at Teneriffe *tano*, at Lanzerota *triffa*; barley, in the grand Canary, bore the name of *aramotanoque*, and at Lanzerota that of *tamosen*. The flower of roasted barley (*gofio*) and goat's milk constituted the principal food of this nation, on the origin of which so many systematic fables have been built. These aliments are sufficient proofs, that the race of the Guanches belonged to the nations of the old continent, perhaps to those of Caucasus, and not like the rest of the Atlantides\*, to the inhabitants of the New World; these, before the arrival of the Europeans, were unacquainted with corn, and milk, and cheese.

A great number of chapels, which the Spaniards call *ermitas*, encircle the town of Laguna. Shaded by trees of perpetual verdure, and placed on small eminences, these chapels add to the picturesque effect of the landscape. The interior

\* Without entering here into any discussion respecting the existence of the Atlantis, I shall cite the opinion of Diodorus Siculus, according to whom the Atlantides were ignorant of the use of corn, because they were separated from the rest of mankind before these gramina were cultivated. *Diod. Sicul.* t. iii, p. 130, Wessel.

side of the town is not equal to it's external appearance. The houses are solidly built, but very antique, and the streets seem deserted. A botanist ought not to complain of the antiquity of the edifices. The roofs and walls are covered with Canary house-leek, and those elegant trichomanes, mentioned by every traveller. These plants are nourished by the frequent fogs.

Mr. Anderson, the naturalist in the third voyage of Captain Cook, advises the European physicians to send their sick to Teneriffe, undoubtedly not from those motives, which induce some practitioners to prefer the mineral waters that are at the greatest distance, but on account of the mildness of the temperature and equal climate of the Canaries. The ground on these islands rises in an amphitheatre, and presents simultaneously, as in Peru and Mexico, the temperature of every climate, from the heats of Africa to the cold of the higher Alps. Santa Cruz, the port of Orotava, the town of the same name, and that of Laguna, are four places, the mean temperatures of which form a descending series. In the south of Europe, the change of the seasons is still too perceptible, to offer the same advantages. Teneriffe on the contrary, situate as it were on the threshold of the tropics, though but a few days' sail from Spain, shares in the beauties, which nature has lavished on the equinoctial regions. Vegetation here displays some of

it's fairest and most majestic forms in the banana and the palm-tree. He who is awake to the charms of nature finds in this delicious island remedies still more potent than the climate. No abode appeared to me more fitted to dissipate melancholy, and restore peace to the perturbed mind, than that of Teneriffe, or Madeira. These advantages are the effect not of the beauty of the site and the purity of the air alone ; the moral feeling is no longer harrowed up by the view of slavery, the appearance of which is so revolting in the West Indies, and in every other place, whither European planters have conveyed what they call their civilization, and their industry.

In winter the climate of Laguna is extremely foggy, and the inhabitants often complain of the cold. A fall of snow however has never been seen, which may seem to indicate, that the mean temperature of this town must be above  $18\cdot7^{\circ}$  ( $15^{\circ}$  R.) that is to say, exceeding that of Naples. I do not lay this down as a rigorous conclusion ; for in winter, the refrigeration of the clouds does not depend so much on the mean temperature of the whole year, as on the instantaneous diminution of heat, to which a district is exposed by it's local situation. The mean temperature of the capital of Mexico, for instance, is only  $16\cdot8^{\circ}$  ( $13\cdot5^{\circ}$  R.), nevertheless, in the space of a hundred years, snow has fallen only once, while in the south of Europe, and in Africa, it snows in

places where the mean temperature is above 19 degrees.

The vicinity of the sea renders the climate of Laguna more temperate in winter, than it would otherwise be on account of it's elevation above the level of the ocean. I was even astonished to learn, that Mr. Broussonet had planted in the midst of this town, in the garden of the Marquis de Nava, the bread-fruit tree (*artocarpus incisa*), and cinnamon tree (*laurus cinnamomum*). These valuable productions of the South Sea and the East Indies are naturalized there as well as at Orotava. Does not this attempt prove, that the bread-fruit might flourish in Calabria, Sicily, and Grenada? The culture of the coffee tree has not equally succeeded at Laguna, though it's fruit ripens at Teguesta, as well as between the port of Orotava and the village of St. Juan de la Rámbla. It is probable, that some local circumstances, perhaps the nature of the soil, and the winds that prevail in the flowering season, are the cause of this phenomenon. In other regions, in the neighbourhood of Naples for instance, the coffee-tree produces abundantly, though the mean temperature scarcely rises above 18 centigrade degrees.

No person has ascertained, in the island of Teneriffe, the lowest height at which snow falls every year. This fact, easy of execution by barometrical measurements, has hitherto been ge-



nerally neglected under every zone; it is nevertheless highly interesting both to agriculture in the colonies and meteorology, and full as important as the measure of the limit of the perpetual snows. My observations furnished me with the data, which I shall record in the following table.

Northern latitude.	Lowest height at which the snow falls.		Inferior limit of the perpetual snows.		Difference of the two preceding columns.		Mean Temperature.	
	toises.	metres.	toises.	metres.	toises.	metres.	Cent.	Reau.
0°	2040	3976	2460	4794	420	818	27°	21·6°
20	1550	3020	2360	4598	810	1578	24·5	19·6
40	0	0	1540	3001	1540	3001	17	13·6

This table presents only the ordinary state of nature, that is to say, the phenomena as they are annually observed. Exceptions founded on particular local circumstances, exist. Thus it sometimes snows, though seldom, at Naples, at Lisbon, and even at Malaga, consequently as low as the 37th degree of latitude: and, as we have just observed, snow has been seen to fall at Mexico, the elevation of which is 1173 toises above the level of the Ocean. This phenomenon, which had not been seen for several centuries, took place on the day that the Jesuits were expelled, and was attributed by the people to this act of severity. A more striking exception was found in the climate of Valladolid, the capital of



the province of Mechoacan. According to my measures, this height of the town, situate in  $19^{\circ} 42'$  of latitude, is only a thousand toises: and yet, a few years before our arrival in New Spain, the streets were covered with snow for some hours.

Snow has been seen to fall also at Teneriffe, in a place lying above Esperanza de la Laguna, very near the town of this name, in the gardens of which the artocarpus flourishes. This extraordinary fact was confirmed to Mr. Broussonet by very aged persons. The *erica arborea*, the *myrica faya*, and the *arbutus callicarpa*\*, did not suffer from this snow; but it destroyed all the swine in the open air. This observation is interesting to vegetable physiology. In hot countries, the plants are so vigorous, that cold is less injurious to them, provided it be of short duration. I have seen the banana cultivated in the island of Cuba, in places where the thermometer descends to seven centesimal degrees, and sometimes very near the freezing point. In Italy and Spain the orange and date trees do not perish, though the cold during the night is two degrees below the freezing point. In general it is remarked by cultivators, that the trees which grow in a fertile soil are less delicate, and consequent-

\* This fine *arbutus*, imported by Mr. Broussonet, is very different from the *arbutus laurifolia*, with which it has been confounded, and which belongs to North America.

ly less affected by great changes in the temperature, than those which grow in land that affords but little nutriment \*.

In order to pass from the town of Laguna to the port of Orotava and the western coast of Teneriffe, we cross at first a hilly region covered with black and argillaceous earth, in which are found some small crystals of pyroxene. The waters most probably detach these crystals from the neighbouring rocks, as at Frascati near Rome. Unhappily, strata of ferruginous earth conceal the soil from the researches of the geologist. It is only in some ravines, that we find columnar basalts, somewhat curved, and above them very recent breccia, resembling volcanic tufa. These breccia contain fragments of the same basalts which they cover; and it is asserted, that marine petrifications are observed in them. The same phenomenon occurs in the Vicentin, near Montechio Maggiore.

The valley of Tacoronte is the entrance into this charming country, of which travellers of every nation have spoken with rapturous enthu-

\* The mulberries, cultivated in the meagre and sandy soils of countries bordering on the Baltic Sea, are examples of this feebleness of organization. The late frosts do more injury to them, than to the mulberries of Piedmont. In Italy a cold of  $5^{\circ}$  below the freezing point does not destroy robust orange trees. According to Mr. Galesio, these trees, less tender than the lemon and bergamot orange trees, freeze only at ten centesimal degrees below the freezing point.

siasm. Under the torrid zone I found sites, where nature is more majestic, and richer in the display of organic forms; but after having traversed the banks of the Oroonoko, the Cordilleras of Peru, and the most beautiful vallies of Mexico, I own, that I have never beheld a prospect more varied, more attractive, more harmonious in the distribution of the masses of verdure and of rocks.

The seacoast is lined with date and cocoa trees. Groups of musa, as the country rises, form a pleasing contrast with the dragon-tree, the trunks of which have been justly compared to the tortuous form of the serpent. The declivities are covered with vines, which throw their branches over towering poles. Orange trees loaded with flowers, myrtles, and cypress trees, entwine the chapels reared to devotion on the isolated hills. The divisions of property are marked by hedges formed of the agave and the cactus. An innumerable quantity of cryptogamous plants, among which ferns are the most predominant, cover the walls, moistened by small springs of limpid water. In winter, when the volcano is buried under ice and snow, this district enjoys perpetual spring. In summer, as the day declines, the breezes from the sea come loaded with delicious coolness. The population of this coast is very considerable; and it appears to be still greater than it is, because the houses and gardens are

more distant from each other, which adds to the picturesque beauty of the situation. Unhappily the real welfare of the inhabitants does not correspond with the exertions of their industry, or with the advantages which nature has lavished on this spot. The farmers are not proprietors; the fruits of their labour belong to the nobles, and those feudal institutions, which, for so long a time, spread misery throughout Europe, still weigh heavily on the happiness of the people of the Canary islands.

From Tegueste and Tacoronte to the village of St. Juan de la Rambla, which is celebrated for it's excellent malmsey, the rising hills are cultivated like a garden. I might compare them to the environs of Capua and Valentia, if the western part of Teneriffe was not infinitely more beautiful on account of the proximity of the peak, which presents on every side a varied landscape. The view of this mountain is interesting not merely from it's gigantic mass: it fills the mind, by carrying it back to the mysterious source of it's volcanic agency. For thousands of years, no flames or light have been perceived on the summit of the Piton, nevertheless enormous lateral eruptions, the last of which took place in 1798, are proofs of the activity of a fire still far from being extinguished. There is also something, that leaves a melancholy impression on the mind on seeing a crater in the centre of



a fertile and well cultivated country. The history of the globe instructs us, that volcanoes destroy what they have been a long series of ages in creating. Islands, which the action of submarine fires has raised above the waters, are decked by degrees in rich and smiling verdure ; but these new abodes are often laid waste by the renewed action of the same power, which caused them to emerge from the bottom of the ocean. Perhaps those islets, which are now but heaps of scorice and volcanic ashes, were once as fertile as the hills of Tacoronte and Sauzal. Happy the country, where man has no distrust of the soil on which he lives !

Pursuing our course to the port of Orotava, we passed the smiling hamlets of Matanza and Vittoria. These names are mingled together in all the Spanish colonies, and form a disagreeable contrast with the feelings of peace and tranquillity, which those countries inspire. *Matanza* signifies butchery, or carnage ; and the word alone recalls the price, at which victory has been purchased. In the New World, it generally indicates the defeat of the natives ; at Teneriffe, the village of Matanza was built in a place\* where the Spaniards were conquered by those same Guanches, who soon after were sold as slaves in the markets of Europe.

Before we reached Orotava, we visited a bo-

\* The ancient Acantejo.



tanic garden at a small distance from the port. We there found Mr. Le Gros, the French vice-consul, who had often scaled the summit of the peak, and who served us as an excellent guide. He was accompanying Captain Baudin in a voyage to the West Indies, which has largely contributed to enrich the garden of plants at Paris. A dreadful tempest, of which Mr. Le Dru has given an account in the narrative of his voyage to Porto Rico, forced the vessel to put into Teneriffe; where Mr. Le Gros was led by the beauty of the spot to settle. It was he who gave the learned of Europe the first accurate ideas of the great lateral eruptions of the peak, which has been very improperly called the explosion of the volcano of Chahorra \*.

The establishment of a botanical garden at Teneriffe is a very happy idea, on account of the double influence, which it may have on the progress of botany, and on the introduction of useful plants into Europe. For the first idea we have of it we are indebted to the Marquis de Nava †, whose name deserves to be recorded with that of Mr. Poivre, and who, habitually engaged in doing good, has made a noble use of his fortune. He undertook, at an enormous expense, to level the hill of Durasno, which now rises as an amphitheatre, and which was begun

\* The 8th of June, 1798.

† Marquis de Villanueva del Prado.

to be planted in 1795. The marquis thought, that the Canary islands, from the mildness of their climate and geographical position, afforded the most suitable place for naturalising the productions of the two Indies, and serving as a repository to habituate the plants gradually to the colder temperature of the south of Europe. In fact, the plants of Asia, Africa, and South America, may easily be brought to Orotava; and in order to introduce the bark-tree \* into Sicily, Portugal, or Grenada, it should be first planted at Durasno, or at Laguna, and the shoots of this tree may afterwards be transported into Europe from the Canaries. In happier times, when maritime wars shall no longer interrupt communication, the garden of Teneriffe may become extremely useful with respect to the great number of plants, which are sent from the Indies to Europe; for ere they reach our coasts, they often perish, on account of the length of the passage, during which they inhale an air impregnated with salt water. These plants would meet at Orotava

\* I speak of the species of bark-tree (*cinchona*), which at Peru, and in the kingdom of New Grenada, flourish on the back of the Cordilleras, at the height of between 1000 and 1500 toises, in places where the thermometer is between nine and ten degrees during the day, and from three to four during the night. The orange bark-tree (*cinchona lancifolia*) is much less tender than the red bark-tree (*c. oblongifolia*). See the Memoir on the Forests of the bark-tree, which I published in 1807, in the *Magasin dar Naturkunde*, B. i. p. 118.

with the care and climate necessary to their preservation. The keeping of the botanic garden having become every year more expensive, the Marquis de Nava has ceded it to the government. We found in it a well-informed gardener, who had been brought up under Mr. Aiton, director of the royal garden at Kew. The earth is raised in terraces, and watered by a natural spring. It has a view of the island of Palma, which appears like a castle in the midst of the ocean. We found this establishment but little stocked with plants, vacant places of genera were filled up with thickets, the names of which seemed to have been taken by chance, as they were found in the *systema vegetabilium* of Linnaeus. This distribution of plants, after the classes of the sexual system, which is unhappily the case in several gardens in Europe, is very hostile to their cultivation. At Durasno, the protei, the psidium, the jambos, the chirimoya of Peru \*, sensitive plants, and heliconias, flourish in the open air. We gathered the ripened seeds of several beautiful species of glycine from New Holland, which the governor of Cumana, Mr. Emparan, successfully cultivated, and which since grow wild on the coasts of South America.

We arrived very late at the port of Orotava †,

\* *Annona cherimolia*. Lamarck.

† Puerto de la Cruz. The only fine port of the Canary islands is that of St. Sebastien, in the isle of Gomera.

if we may give the name of port to a road, in which the vessels are obliged to put to sea whenever the winds blow violently from the northwest. It is impossible to speak of Orotava, without recalling to the remembrance of the scientific world the name of Mr. Cologan, whose house at all times was open to travellers of every nation. Several members of this respectable family have been educated at London and at Paris. Don Bernardo Cologan unites the most ardent zeal for the good of his country to various parts of solid instruction. We are agreeably surprised to find, in a group of islands near the coasts of Africa, that urbanity, that taste for knowledge, that love of the arts, which is thought to belong exclusively to a small part of Europe.

We could have wished to have sojourned for some time in Mr. Cologan's house, and visited with him the charming scenery of St. Juan de la Rambla and of Rialexo de Abaxo \*. But on a voyage such as that we had undertaken, the present is but little enjoyed. Continually haunted by the fear of not executing the designs of the morrow, we live in perpetual uneasiness. Persons who are passionately fond of nature and the arts, feel the same sensations, when they travel through Switzerland and Italy. Enabled

\* The last of these two villages is placed at the foot of the lofty mountain of Tygayga.



to see but a small portion of the objects which allure them, they are disturbed in their enjoyments by the restraints they impose on themselves at every step.

On the morning of the 21st of June, we were already on the road for the summit of the volcano. Mr. Le Gros, whose attentions were unwearied, Mr. Lalande, secretary of the French Consulate at Santa Cruz, and the English gardener at Durasno, shared in the fatigues of this excursion. The day was not very fine, and the summit of the peak, which is generally visible at Orotava from sunrise till ten o'clock, was covered with thick clouds. There is only one path to the volcano, by the *Villa de Orotava*, the *Plain of Spartium*, and the *Malpais*; it is this which was taken by father Feuillée, Borda, La Billardiére, Barrow, and all late travellers, who have made but a short stay at Teneriffe. In an excursion to the peak, as well as in those which are commonly made in the valley of Chamouni and to the top of Etna, where we are forced to follow the guide, we see almost nothing but what has been already seen and described by former travellers.

We were agreeably surprised by the contrast between the vegetation of this part of Teneriffe, and that of the environs of Santa Cruz. Under the influence of a cool and humid climate, the ground was covered with beautiful verdure;



while on the road from Santa Cruz to Laguna the plants exhibited nothing but pods emptied of their seeds. Near the port of Santa Cruz, the strength of the vegetation is an obstacle to geological researches. We went on foot over two small hills, which rise in the form of bells. Observations made at Vesuvius, and in Auvergne, lead us to think, that these paps owe their origin to lateral eruptions of the great volcano. The hill called *Montannita de la Villa* seems indeed to have already emitted lavas; and according to the tradition of the Guanches this eruption took place in 1430. Colonel Franqui assured Borda, that the place is still to be seen whence the melted matter issued; and that the ashes, which covered the ground adjacent, were not yet productive\*. Wherever the rock appears, we discovered basaltic amygdaloid † co-

\* This fact is taken from a manuscript now at Paris, at the dépôt of the Charts of the Marine. It bears the title of *Résumé des Operations de la Campagne de la Boussole (in 1776) pour déterminer les Positions géographiques des Côtes d'Espagne & de Portugal sur l'Océan, d'une Partie des Côtes occidentales de l'Afrique, & des Iles Canaries, par le Chevalier de Borda*. This is the manuscript of which Mr. Fleurieu speaks in the notes, which he has added to the Voyage of Marchand, vol. ii, p. 11, and which M. de Borda had communicated to me previous to my departure. As I have extracted some important observations from it, which have never been published, I shall cite it in this work under the title of *Manuscript du Dépôt*.

† Basaltartiger mandelstein. Werner.

vered with hardened clay \*, which contains *rapilli*, or fragments of pumice stone. This last formation resembles the tufas of Pausilippo, and the strata of Puzzolana, which I found in the valley of Quito, at the foot of the volcano of Pichincha. The amygdaloid has very long pores, like the superior strata of the lavas of Vesuvius, arising probably from the action of an elastic fluid forcing it's way through the matter in fusion. Notwithstanding these analogies, I must here repeat, that in all the low region of the peak of Teneriffe, on the side of Orotava, I have met with no flow of lavas, no current, the limits of which were strongly marked. Torrents and inundations change the surface of the globe, and when a great number of currents of lava meet and spread over a plain, as I have seen at Vesuvius, in the *Atrio Dei Cavalli*, they seem to be confounded together, and wear the appearance of real strata.

The *villa de Orotava* has a pleasant aspect at a distance, from the great abundance of waters which run through the principal streets. The spring of *Agua mansa*, collected in two large reservoirs, turns several mills, and is afterward discharged among the vineyards of the adjacent hills. The climate is still more refreshing at the *villa* than at the port of La Cruz, from the in-

\* Bimstein-conglomerat. W.

fluence of the breeze, which blows strong after ten in the morning. The water, which has been dissolved in the air at a higher temperature, frequently precipitates itself, and renders the climate very foggy. The villa is nearly 160 toises (312 metres) above the surface of the ocean, consequently 200 toises less than the ground on which Laguna is built ; it is observed also, that the same kind of plants flower a month later in this latter place.

Orotava, the ancient Taoro of the Guanches, is placed on a very steep declivity ; the streets seem deserted ; the houses, solidly built, but of a gloomy appearance, belong almost all to the nobility, who are accused of being extremely haughty, and who give themselves the pompous title of the *doze casas* (the twelve houses). We passed along a lofty aqueduct, lined with a great number of fine ferns ; and visited several gardens, in which the fruit trees of the north of Europe are mingled with orange trees, pomegranate, and date trees. We were assured, that these last were as little productive here as on the coasts of Cumana. Although we were acquainted, from the narratives of so many travellers, with the dragon-tree of the garden of Mr. Franqui, we were not the less struck with it's enormous magnitude. We were told, that the trunk of this tree, which is mentioned in several very ancient documents as marking the boundaries of a field,

was as gigantic in the fifteenth century, as it is at the present moment. Its height appeared to us to be about 50 or 60 feet ; its circumference near the roots is 45 feet. We could not measure higher, but Sir George Staunton found, that, 10 feet from the ground, the diameter of the trunk is still 12 English feet ; which corresponds perfectly with the assertion of Borda, who found its mean circumference 33 feet 8 inches, French measure. The trunk is divided into a great number of branches, which rise in the form of a candelabrum, and are terminated by tufts of leaves, like the yucca which adorns the valley of Mexico. It is this division, which gives it a very different appearance from that of the palm-tree\*.

Among organised beings, this tree is undoubtedly, together with the *adansonia* or baobab of Senegal, one of the oldest inhabitants of our globe. The baobabs are of still greater dimensions than the dragon-tree of Orotava. There are some, which near the root measure 34 feet in diameter, though their total height is only from 50 to 60 feet†. But we should observe,

\* I have given, in the Picturesque Atlas which accompanies this narrative, (Pl. 58 of the folio Atlas,) the figure of the dragon-tree of Franqui, from a sketch made in 1776 by M. D'Ozonne, at the time of the expedition of Messrs. de Borda and Varela.

† Adanson is surprised, that the baobabs have not been cited by other travellers. I find, in the collection of Grynæus, that Aloysio Cadamosto speaks of the great age of



that the *adansonia*, like the *ochroma*, and all the plants of the family of *bombax*, grow much more rapidly \* than the *dracœna*, the vegetation of which is very slow. That in Mr. Franqui's garden bears still every year both flowers and fruit. Its aspect feelingly recalls to mind "that eternal youth † of nature," which is an inexhaustible source of motion and of life.

The *dracœna*, which is seen only in cultivated

those monstrous trees, which he saw in 1504, and of which he says very truly, "*eminentia altitudinis non quadrat magnitudini.*" Cadam. Navig. chap. 42. At Senegal, and near Praya, in the islands of Cape Verd, Messrs. Adanson and Staunton remarked *adansoniæ*, the trunks of which were from 56 to 60 feet in circumference. Voy. au Sénégal, t. i, p. 54. The baobab 34 feet in diameter was seen by Mr. Golberry, in the valley of the two Gagnacks. *Fragmens d'un Voy. en Afrique*, t. ii, p. 92.

\* It is the same with the plane-tree (*platanus occidentalis*) which Mr. Michaux measured at Marietta, on the banks of the Ohio, and which, at twenty feet from the ground, was 15·7 feet in diameter (*Voy. à l'Ouest des Monts Alleghany*, 1804, p. 93). The *taxus*, *chesnut*, *oak*, *plane-tree*, *cupressus disticha*, *bombax*, *mimosa*, *cæsalpinia*, *hymenea*, and *dracœna*, appear to me to be the plants, which, in different climates, offer specimens of the most extraordinary growth. An oak, discovered together with some Gallic helmets in 1809, in the turf pits of the department of the Somme, near the village of Yseux, seven leagues from Abbeville, was about the same size as the dragon-tree of Orotava. According to a memoir by Mr. Traullée, the trunk of this oak was 14 feet in diameter.

† Aristot. de Longit. Vitæ, cap. vi, (ed Casaub. p. 442.)



spots in the Canary islands, at Madeira, and Porto Santo, offers a curious phenomenon with respect to the migration of plants. It has never been found in a wild state on the continent of Africa\*: the East Indies is its real country. By what means has this tree been transplanted to Teneriffe, where it is no way common? does its existence prove, that, at some very distant epocha, the Guanches had connections with other nations originally from Asia?

On leaving Orotava, a narrow and stony pathway led us across a beautiful forest of chesnut trees, *el monte de Castannos*, to a site which is covered with brambles, some species of laurels,

\* Mr. Schousboe, in his *Flora of Morocco* (*Danske Videnskabs-Selskabs Skrifter*, B. v, p. 4) does not even mention it among the cultivated plants, while he speaks of the cactus, the agave, and the yucca. The form of the dragon-tree is exhibited in several species of the genus *dracæna*, at the Cape of Good Hope, in China, and in New Zealand; but in the New World it is replaced by the form of the yucca; for the *dracæna borealis* of Aiton is a *convallaria*, of which it has all the appearance. The astringent juice, known in commerce by the name of dragon's blood, is, according to the inquiries we made on the spot, the produce of several American plants, which do not belong to the same genus, and of which some are liannest. At Laguna, toothpicks steeped in the juice of the dragon-tree are made in the nunneries, and are much extolled as highly useful for the preservation of the gums.

† A general term used for climbing plants in the French West India islands. ED.

and arborescent heaths. The trunks of the last grow to an extraordinary size ; and the flowers with which they are loaded form an agreeable contrast, during a great part of the year, with the *hypericum canariense*, which is very abundant at this height. We stopped to take in our provision of water under a solitary fir-tree. This station is known in the country by the name of *Pino del Dornajito* ; it's height, according to the barometrical measurement of Mr. de Borda\* is 522 toises ; and it commands a magnificent prospect of the sea, and the whole of the northern part of the island. Near Pino del Dornajito, a little on the right of the pathway, is a copious spring of water, into which we plunged the thermometer, which fell to  $15.4^{\circ}$ . At a hundred toises distance from this spring is another equally limpid. If we admit, that these waters indicate nearly the mean heat of the place whence they issue, we find the absolute elevation of the

\* *Manuscrit du Dépôt, 7me cahier, p. 15.* I calculated the heights, which I mention in the text, according to the formula of Mr. Laplace, and the coefficient of Mr. Ramond. In the manuscript, we find " 516 toises, according to the tables of De Luc." We must not confound the Pino del Dornajito with the station of the *Pino de la Merienda*, cited by Eden and father Feuillée ; and elevated 800 toises above the level of the ocean. This last station is between the Caravela and the Portillo. See the note on the whole of these measures, at the end of the *Journal de Route*.

station 520 toises, supposing \* the mean temperature of the coast to be  $21^{\circ}$ , and allowing one degree for the decrement of caloric corresponding under this zone to 93 toises. We should not be surprised, if this spring remained a little below the heat of the air, since it is probably formed in some more elevated part of the peak, and communicates perhaps even with the small subterranean glaciers, of which we shall speak hereafter. The accordance which we have just observed between the barometrical and thermometrical measures is so much the more striking because in general, as I have elsewhere explained †, in mountainous countries, with steep de-

\* As a proof that these objections are founded on accurate observations, I will here observe, that the mean temperature of the low regions of the isle of Madeira, which is a little to the north of Teneriffe, is  $20.4^{\circ}$ ; and that my observations, made under the torrid zone, allow for the decrement of caloric 98 toises to each centesimal degree; while the results taken by Mr. Ramond, under the temperate zone, in latitude  $45^{\circ}$ , give 84 toises. From these extremes it follows, that the height of the Dornajito is either 548 toises, or 470 toises. Mr. de Borda found in 1776 the temperature of the air near the spring  $5^{\circ}$  colder than at the port of Orotava, which seems to prove, that the decrement of 93 toises, which I have supposed, is not too slow. *Phil. Trans.* vol. xlvii, p. 358. Ramond, *Mém. sur la Formula barom.* p. 189.

† *Astron. Obs.*, vol. i, p. 132. Thus in the Blue Mountains of Jamaica Mr. Hunter found springs constantly colder than they ought to have been, according to the height at which they issued.

clivities, the springs indicate too great a decrement of caloric, because they unite small currents of water, which filter at different heights, and their temperature is consequently the mean between the temperature of these currents. The spring of Dornajito has considerable reputation in the country ; and was the only one known, at the time of my excursion, on the road which leads to the summit of the volcano. The formation of springs demands a certain regularity in the direction and inclination of the strata. On a volcanic soil, porous and splintered rocks absorb the rain waters, and lead them to considerable depths. Hence arises that aridity observed in the greater part of the Canary islands, notwithstanding the considerable height of their mountains, and the mass of clouds which navigators behold incessantly piled over this archipelago.

From Pino del Dornajito to the crater of the volcano we continued to ascend without crossing a single valley ; for the same ravines (*barancos*) do not merit this name. To the eyes of the geologist the whole of the isle of Teneriffe is but one mountain, the almost elliptical base of which is prolonged to the north-east, and in which we distinguish several systems of volcanic rocks formed at different epochas. The *Chahorra*, or *Montana Colorada*, and the *Urca*, considered in the country as insulated volcanoes, are only lit-



the hills abutting on the peak, and marking it's pyramidal form. The great volcano, the lateral eruptions of which have given birth to vast promontories, is not however precisely in the centre of the island, and this peculiarity of structure appears less surprising, if we recollect, as a learned mineralogist has observed\*, that it is not perhaps the small crater of the Piton, which has acted the principal part in the revolutions undergone by the isle of Teneriffe.

Above the region of arborescent heaths, called *Monte Verde*, is the region of the ferns. No where, under the temperate zone, have I seen such an abundance of the pteris, blechnum, and asplenium; yet none of these plants have the stateliness of the arborescent ferns, which at the height of five or six hundred toises form the principal ornament of equinoctial America. The root of the pteris aquilina serves the inhabitants of Palma and Gomera for food; they grind it to powder, and mix with it a small quantity of barley-meal. This composition, when boiled, is called *gofio*; the use of so homely an aliment is a proof of the extreme penury of the lower order of people in the Canary islands.

Monte Verde is intersected by several small and very arid ravines (*cannadas*), and the region of ferns is succeeded by a wood of juniper trees

\* Mr. Cordier.



and firs, which has suffered greatly from the violence of the hurricanes. In this place, mentioned by some travellers under the name of Caravela, Mr. Eden \* asserts that he saw little flames, which, according to the doctrine of the naturalists of his time, he attributes to sulphurous exhalations that take fire of themselves. We continued to ascend, till we came to the rock of La Gayta and to Portillo ; traversing this narrow passage between two basaltic hills, we entered the great plain of Spartium†. At the time of the voyage of La Peyrouse, Mr. Manneron had taken the levels of the peak, from the port of Orotava to this elevated plain near 1400 toises above the level of the sea ; but the want of water, and the misconduct of the guides, had prevented him from taking the levels to the top of the volcano. The results of this operation, which was two thirds finished, unfortunately were not sent to Europe, and this work is still to be recommenced from the seacoast.

We spent two hours and a half in crossing the Llano del Retama, which appears like an immense sea of land. Notwithstanding the elevation of this site, the centigrade thermometer

\* This visit took place in 1715. Phil. Trans. vol. xxix, p. 317. Carabela is the name of a vessel with latin sails. The pines of the peak formerly were used as masts of vessels, and the royal navy cut it's wood (*cortes de madera*) on the Monte Verde.

† Los Llanos del Retama.

rose in the shade, toward sunset, to  $13\cdot8^{\circ}$ , or  $3\cdot7^{\circ}$  higher than toward noon at Monte Verde. This augmentation of heat could be attributed only to the reverberation from the ground, and the extent of the plain. We suffered much from the suffocating dust of the pumice stone, in which we were continually enveloped. In the midst of this plain are tufts of the *retama*, which is the *spartium nubigenum* of Aiton. This charming shrub, which Mr. de Martiniere\* wished to introduce into Languedoc, where firewood is very scarce, grows to the height of nine feet; it is loaded with odoriferous flowers, with which the goat hunters, that we met in our road, had decorated their hats. The goats of the peak, which are of a deep brown, are reckoned delicious food; they browse on the *spartium*, and have run wild in the deserts from time immemorial. They have even been transported to Madeira, where they are preferred to the goats of Europe.

As far as the rock of Gayta, or the entrance of the extensive Llano del Retama, the peak of Teneriffe is covered with beautiful vegetation: nothing bears the mark of recent devastation. We might have imagined ourselves scaling the side of some volcano, the fire of which had been extinguished as remotely as that of Monte Cavo,

\* One of the botanists who perished in the expedition of La Peyrouse.

near Rome; but scarcely had we reached the plain covered with pumice stone, when the landscape changed its aspect, and at every step we met with large blocks of obsidian thrown out by the volcano. Every thing here speaks perfect solitude. A few goats and rabbits only bound across the plain. The barren region of the peak is nine square leagues; and as the lower regions viewed from this point shrink in the prospect, the island appears an immense heap of torrefied matter, hemmed round by a scanty border of vegetation.

From the region of the *spartium nubigenum* we passed through narrow defiles, and small ravines hollowed very anciently by the torrents, first to a more elevated plain (*el Monton de Trigo*), then to the place where we intended to pass the night. This station, which is more than 1530 toises above the coast, bears the name of the English Halt (*Estancia de los Ingleses\**), no doubt because English travellers were those, who formerly visited the peak most frequently. Two

\* This denomination was already in use at the beginning of the last century. Mr. Eden, who corrupts all Spanish words, as do the greater part of travellers in our own times, calls it the *Stancha*: it is the *Station des Rochers* of Mr. Borda, as is proved by the barometrical heights there observed. These heights were in 1803, according to Mr. Cordier, 10 inches 9·5 lines; and in 1776, according to Messrs. Borda and Varela, 19 inches 9·8 lines; the barometer at Orotava keeping within nearly a line at the same height.

inclined rocks form a kind of cavern, that affords a shelter from the winds. This point, already higher than the summit of Canigou, can be reached on the backs of mules ; and here ends the expedition of numbers of travellers, who on leaving Orotava had hoped to have ascended to the brink of the crater. Though in the midst of summer, and under the bright sky of Africa, we suffered from the cold during the night. The thermometer descended as low as to five degrees. Our guides made a large fire with the dry branches of retama. Having neither tents nor cloaks, we lay down on a heap of burnt rocks, and were singularly incommoded by the flame and smoke, which the wind drove toward us. We had attempted to form a kind of screen with cloths tied together, but our enclosure took fire, which we did not perceive, till the greater part had been consumed by the flames. We had never passed a night on a point so elevated, and did not then conjecture, that on the ridge of the Cordilleras we should one day inhabit towns higher than the summit of the volcano we were to scale on the morrow. As the temperature diminished, the peak became covered with thick clouds. The approach of night interrupts the play of the ascending current, which, during the day, rises from the plains toward the high regions of the atmosphere ; and the air, in cooling, loses it's capacity of suspending water. A strong



northerly wind chased the clouds ; the moon at intervals, shooting across the vapors, exposed it's disk on a firmament of the darkest blue ; and the view of the volcano threw a majestic character over the nocturnal scenery. Sometimes the peak was entirely hidden from our eyes by the fog, at others, it broke upon us in terrific nearness ; and, like an enormous pyramid, threw it's shadow over the clouds rolling beneath our feet.

Towards three in the morning, by the sombrous light of a few fir torches, we began our expedition for the summit of the Piton. We scaled the summit on the north-east, where the declivities are extremely steep ; and we came, after two hours toil, to a small plain, which, on account of its isolated situation, bears the name of *Alta Vista*. It is the station also of the *neveros*, those natives, whose occupation it is to collect ice and snow, which they sell in the neighbouring towns. Their mules, better practised in climbing mountains than those hired by travellers, reach *Alta Vista*, and the *neveros* are obliged to transport the snow to this place on their backs. Above this point the *Malpays* begins, a term by which is designated here, as well as in Mexico, Peru, and every other country subject to volcanoes, a ground destitute of vegetable mould, and covered with fragments of lavas.

We turned towards the right to examine the



*Cavern of Ice*, which is at 1728 toises, consequently below the limit of the perennial snows under this zone. It is probable, that the cold which reigns in this cavern is owing to the same causes, which perpetuate the ice in the crevices of Mount Jura, and the Apennines, and on which the opinions of naturalists are still much divided\*. This natural ice-house of the Peak has nevertheless none of those perpendicular openings, which give emission to the warm air, while the cold air remains undisturbed at the bottom. It seems that the ice is preserved in it on account of it's mass, and because it's melting is retarded by the cold, which is the consequence of quick evaporation. This small subterraneous glacier is situate in a region, the mean temperature of which is probably not under three degrees ; and it is not, like the true glaciers of the Alps, fed by the snow waters that flow from the summits of the mountains. During winter, the cavern is filled with ice and snow ; and as the rays of the

\* Saussure, Voyage dans les Alpes, § 1406—1414. Prevost, du Calorique rayonnant, p. 409—422. In the greater part of the *cellars of ice*, for instance that of St. George, between Niort and Rolle, a thin layer of limpid ice forms itself in summer on the walls of the calcareous rock. Mr. Pictet observed, that at this epocha the thermometer does not descend, in the air of the cellar, below two or three degrees, so that we must attribute the congelation to a local and very rapid evaporation.

sun do not penetrate beyond the mouth, the heats of summer are not sufficient to empty the reservoir. The existence of a natural ice house depends, consequently, rather on the quantity of snow which enters it in winter, and the small influence of the warm winds that blow in summer, than on the absolute elevation of the cavity, and the mean temperature of the layer of air in which it is situate. The air contained in the bowels of a mountain is not easily displaced, as is proved by Monte-Testaceo, at Rome, the temperature of which is so different from that of the surrounding atmosphere. We shall see in the course of this work, that on Chimborazo enormous heaps of ice are found covered with sand, and, in the same manner, as at the Peak, far below the inferior limit of the perpetual snows.

It was near the Cellar of Ice (*Cueva del Hielo*), that, in the voyage of La Peyrouse, Messrs. Lamanon and Mongès made their experiments on the temperature of boiling water. These naturalists found it  $88.7^{\circ}$ , the barometer being at nineteen inches one line. In the kingdom of New Grenada, at the chapel of Guadaloupe, near Santa-Fe de Bogota, I have seen water boil at  $89.9^{\circ}$ , under a pressure of 19 inches 1.9 lines. At Tambores, in the province of Popayan, Mr. Caldas found the heat of boiling water  $89.5^{\circ}$ , the barometer being at 18 inches 11.6 lines. These results might lead us to suspect, that, in the ex-

periment of Mr. Lamanon, the water had not reached the maximum of it's temperature\*.

The dawn appeared when we left the cavern of ice. We observed, during the twilight, a phenomenon which is not unusual on high mountains, but which the position of the volcano, that we were scaling, rendered very striking. A layer of white and fleecy clouds concealed from us the sight of the ocean, and the lower region of the island. This layer did not appear above 800 toises high; the clouds were so uniformly spread, and kept so perfect a level, that they wore the appearance of a vast plain covered with snow. The colossal pyramid of the peak, the volcanic summits of Lanzerota, of Fortaventura, and the isle of Palma, were like rocks amidst this vast sea of vapors, and their black tints were in fine contrast with the whiteness of the clouds.

While we were climbing over the broken lavas of the Malpays, we perceived a very curious optical phenomenon, which lasted eight minutes. We thought we saw on the east side small rockets thrown into the air. Luminous points, about seven or eight degrees above the horizon, appeared first to move in a vertical direction; but their motion was gradually changed into a real horizontal oscillation. Our fellow travellers, our

\* A calculation, made according to the tables of Mr. Dalton, gives  $89^{\circ}4'$  for La Cueva, and  $89^{\circ}5'$  for Guadaloupe.

guides even, were astonished at this phenomenon, without our having made any remark on it to them. We thought at first sight, that these luminous points, which floated in the air, indicated some new eruption of the great volcano of Lanzerota. We recollected, that Bouguer and La Condamine, in scaling the volcano of Pichincha, were witnesses of the eruption of Cotopaxi ; but the illusion soon ceased, and we found, that the luminous points were the images of several stars magnified by the vapors. These images remained motionless at intervals, they then seemed to rise perpendicularly, descended sideways, and returned to the point whence they had departed. This motion lasted one or two seconds. Though we had no exact means of measuring the greatness of the lateral shifting, we did not less distinctly observe the path of the luminous point. It did not appear double from an effect of looming (*mirage*), and left no trace of light behind. Bringing, with the telescope of a small sextant by Troughton, the stars into contact with the lofty summit of a mountain in Lanzerota, I observed, that the oscillation was constantly directed toward the same point, that is to say, toward the part of the horizon where the disk of the sun was to appear ; and that, making allowance for the motion of the star in it's declination, the image returned always to the same place. These appearances of lateral refraction



ceased long before daylight had rendered the stars quite invisible. I have faithfully related what we saw during the twilight, without undertaking to explain this extraordinary phenomenon, of which I published an account in Baron Zach's Astronomical Journal, twelve years ago. The motion of the vesicular vapours, caused by the rising of the sun ; the mingling of several layers of air, the temperature and density of which were very different, no doubt contributed to produce an apparent movement of the stars in the horizontal direction. We see something similar in the strong undulations of the solar disk, when it cuts the horizon ; but these undulations seldom exceed twenty seconds, while the lateral motion of the stars, observed at the Peak, at more than 1800 toises, was easily distinguished by the sight alone, and seemed to exceed all that we have thought it possible to consider hitherto as the effect of the refraction of the light of the stars. On the top of the Andes, at Antisana, I was present at sunrise, and passed the whole night at 2100 toises, without noting any appearance resembling this phenomenon.

I was anxious to make an exact observation of the instant of sunrising at an elevation so considerable as that we had reached on the Peak of Teneriffe. No traveller, furnished with instruments, had as yet taken such an observation. I



had a telescope, and a chronometer, of which I knew the great exactness. In the part where the sun was to appear, the horizon was free from vapors. We perceived the upper limb at 4<sup>h</sup> 48' 55" apparent time, and what is very remarkable, the first luminous point of the disk was found immediately in contact with the limit of the horizon ; consequently we saw the true horizon, that is to say, a part of the sea farther than 43 leagues. It is proved by calculation, that, under the same parallel in the plain, the rising would have begun at 5<sup>h</sup> 1' 50.4", or 11' 51.3" later than at the height of the Peak. The difference observed was 12' 55", which arose no doubt from the uncertainty of the refraction for a zenith distance, of which observations are wanting\*.

We were surprised at the extreme slowness, with which the lower limb of the sun seemed to

\* In this calculation we have supposed, that for an apparent zenith distance of  $91^{\circ} 54'$ , there are 57' 7" of refraction. The rising sun appears sooner at the Peak of Teneriffe than in the plain by the time that it takes to pass through an arc of  $1^{\circ} 54'$ . The greatness of the arc is augmented only 41' for the summit of Chimborazo. The ancients had such exaggerated ideas of the acceleration of the rising of the sun on the top of high mountains, that they admitted, that this luminary was visible on Mount Athos three hours sooner than on the coast of the Egean sea (*Strabo edit. Almeloven*, lib. vii, p. 510) : yet Mount Athos, according to Mr. Delambre, is only 713 toises high. (*Choiseul Gouffier, Voy. pitt. de la Grece*, t. ii, p. 140.)

detach itself from the horizon. This limb was not visible till  $4^h 56' 56''$ . The disk of the sun, much flattened, was well defined ; during the ascent, there was neither double image nor lengthening of the lower part. The duration\* of the sun's rising being triple that which we might have expected in this latitude, we must suppose, that a fog bank, very uniformly extended, concealed the true horizon, and followed the sun in it's ascent. Notwithstanding the libration of the stars† which we had observed toward the east, we could not attribute the slowness of the rising to an extraordinary refraction of the rays occasioned by the horizon of the sea ; for it is precisely at the rising of the sun, as Le Gentil daily observed at Pondicherry, and as I have several times remarked at Cumana, that the horizon sinks, on account of

\* The apparent duration was  $8' 1''$  instead of  $2' 41''$ . Though my journals contain near eighty observations of the rising and setting of the sun, made either during the voyage, or on the coasts, I have never perceived any sensible retardation.

† A celebrated astronomer, Baron Zach, (*Mon. Corres.* 1800, p. 396) has compared this phenomenon of an apparent libration of the stars to that described in the Georgics (lib. i, v. 365). But this passage relates only to the falling stars, which the ancients, as well as our mariners, considered as a prognostic of wind. The Latin poet appears to have imitated the verses of Aratus. (*Diosem.* v. 926, edit. Buhle, i, p. 206. *Lucret.* ii, v. 143.)

the elevation of temperature in the stratum of the air \* which lies immediately over the surface of the ocean.

The road, which we were obliged to find across the Malpays, was extremely fatiguing. The ascent is steep, and the blocks of lava rolled from beneath our feet. I can compare this part of the road only to the *Moraine* of the Alps, or that mass of pebbly stones, which we find at the lower extremity of the glaciers ; at the Peak, the lava, broken into sharp pieces, leaves hollows, in which we risked falling up to our waists. Unfortunately the laziness of our guides contributed to render this ascent more painful. Unlike those of the valley of Chamouni, or the nimble footed Guanches, who could, it is asserted, seize the rabbit or wild goat in it's course, our Canarian guides were models of the phlegmatic : they wished to persuade us the preceding evening, not to go beyond the station of the rocks : every ten minutes they sat down to repose themselves, and when unobserved threw away the specimens of obsidian and pumicestone, which we had carefully collected. We discovered at length, that none of them had ever yet visited the summit of the volcano

After three hours march, we reached, at the extremity of the Malpays, a small plain, called

\* *Biot, Rech. sur les Réfractions extraordinaires*, p. 218, 223, and 228.

la Rambleta, from the centre of which the Piton, or Sugar-loaf, takes it's rise. On the side toward Orotava the mountain resembles those pyramids with steps, that are found at Fayoum and in Mexico: for the elevated plains of Retama and Rambleta form two stages, the first of which is four times higher than the second. If we suppose the total height of the Peak to be 1904 toises, the Rambleta is 1820 toises above the level of the sea. Here are found those spiracles, which are called by the natives the Nostrils of the Peak \*. Watery and heated vapors issue at intervals from several crevices in the ground, and the thermometer rose to  $43.2^{\circ}$ : Mr. Labillardiere had found the temperature of these vapors, eight years before us,  $53.7^{\circ}$ ; a difference which does not perhaps prove so much a diminution of activity in the volcano, as a local change in the heating of it's internal surface. The vapors have no smell, and seem to be pure water. A short time before the great eruption of Mount Vesuvius, in 1805, Mr. Gay-Lussac and myself had observed, that water, under the form of vapor, in the interior of the crater, did not redden paper dipped in sirup of violets. I cannot, however, admit the bold hypothesis of several naturalists, according to which the Nostrils of the Peak are to be consi-

\* Narices del Pico.

dered as the mouths of an immense apparatus of distillation, the lower part of which is placed below the level of the ocean. Since the time that volcanoes have been carefully studied, and that the love of the marvellous has been less observed in works on geology, very well founded doubts have been raised respecting these direct and constant communications between the waters of the sea, and the focus of the volcanic fire \*. We may find a very simple explanation of a phenomenon, that has in it nothing very surprising. The Peak is covered with snow during part of the year ; we ourselves found it still so in the plain of Rambleta. Messrs. O'Donnel and Armstrong discovered in 1806 a very abundant spring in the Malpays, a hundred toises above the cavern of ice, which is perhaps fed partly by this spring. Every thing, consequently, leads us to presume, that the Peak of Teneriffe, like the volcanoes of the Andes, and those

\* This question has been examined with much sagacity by Mr. Breislak, in his *Introduzione alla Geologia*, t. ii, p. 302, 323, 347. Cotopaxi and Popocatepetl, which I have seen ejecting smoke and ashes, in 1804, are farther from the South Sea and the Gulf of the Antilles, than Grenoble is from the Mediterranean, and Orleans from the Atlantic. We must not consider the fact as merely accidental, that we have not yet discovered an active volcano more than 40 leagues distant from the ocean ; but I consider the hypothesis, that the waters of the sea are absorbed, distilled, and decomposed by volcanoes, as very doubtful.



of the island of Manilla, contains within itself great cavities, which are filled with atmospherical water, owing merely to filtration. The aqueous vapours, which are exhaled by the nostrils and crevices of the crater, are only those same waters heated by the interior surfaces down which they flow.

We had yet to scale the steepest part of the mountain, the Piton, which forms the summit. The slope of this small cone, covered with volcanic ashes, and fragments of pumice stone, is so steep, that it would have been almost impossible to reach the top, had we not ascended by an old current of lava, the wrecks of which have resisted the ravages of time. These wrecks form a wall of scorious rocks, which stretches itself into the midst of the loose ashes. We ascended the Piton by grasping these half decomposed scoriæ, the sharp edges of which remained often in our hands. We employed nearly half an hour to scale a hill, the perpendicular height of which is scarcely ninety toises. Vesuvius \*, three times

\* According to the barometrical measurements, which Mr. Leopold von Buch, Mr. Gay-Lussac, and myself, took in 1805, the height of Vesuvius is diminished on the south-west side since the year 1794, where a part of the cone fell in, two days after the ashes had been ejected. Saussure found Vesuvius, in 1773, 609 toises high, at a time when the brinks of the whole of the crater were nearly of the same height. Sir George Shuckburgh measured, in 1776 a hill placed in the midst of the crater; it was 615 toises in height. This hill

lower than the Peak of Teneriffe, is terminated by a cone of ashes almost three times higher, but with a more accessible and easy slope. Of all the volcanoes which I have visited, that of Jorullo, in Mexico, is the only one, that is more difficult to climb than the Peak, because the whole mountain is covered with loose ashes.

When the Sugar loaf (el Piton) is covered with snow, as it is in the beginning of winter, the steepness of its declivity may be very dangerous to the traveller. Mr. Le Gros showed us the place, where Captain Baudin had nearly perished, at the time of his voyage to the Isle of Trinidad. This officer had the courage to undertake, in company with the naturalists Advenier, Mauger, and Riedlé, an excursion to the top of the volcano toward the end of December,

scarcely existed at the time of Saussure's journey, and disappeared in the eruption of 1779. It was the eruption of 1794, which caused the great inequality of the two brinks of the crater; this unevenness was 71 toises in 1805. Mr. Poli found Vesuvius, a short time before, 606 toises in height. Sir G. Shuckburgh reckoned the highest point of the Somma, called *del Vitello*, 584 toises. This observation is not very accordant with the height, which Mr. Gay-Lussac assigns to the highest brink of the crater; for, in 1805, this part of the brink seemed to have the same elevation as the *Punta del Vitello*. I know not where Shuckburgh placed his instrument at the foot of the cone of ashes; for he states this point at only 316 toises of absolute height. The following is a table of the measures made in very calm weather, with a portable cistern barometer by Ramsden.

## I. Measures taken by Mr. Gay-Lussac alone.

July 1805.	Places.	Barom. in lines.	Therm. of Reaum.	Height abo. level of the sea in toises.	
The 28th at 7 in the evening	At the seaside . . . . .	338.5	22°	. . .	These heights, and those that follow, were calculated after the formula of Mr. Laplace. The temperature of the mercury is supposed to be equal to that of the air, and the height of the apartment of the hermit three toises above the small plain of Saint Salvador. The correspondent heights of the barometer and of the thermometer have been interpolated.
at 10 in the evening	At the hermit of S. Salvador's . . . . .	316.3	18	302	
The 29th at 2 in the morning	Idem . . . . .	316.4	19	. . .	
at 3	At the lower brink of the crater in the road . . . . .	300.0	15	. . .	
at 5	Idem . . . . .	300.5	15	530	
at $\frac{1}{2}$ past 5	At the loftiest brink of the crater . . . . .	295.4	14.4	606	
at $\frac{1}{2}$ past 7	At the beginning of the cone of ashes . . . . .	311.5	18	375	
at $\frac{1}{2}$ past 11	At the hermit's . . . . .	317.1	22		

## II. Measures taken by Messrs. Gay-Lussac, Buch, and Humboldt.

August, 1805.	Places.	Barom. in lines.	Therm. of Reaum.	Height abo. level of the sea in toises.	
The 4th at 5 in the morning	Small elevated plain of the hermitage . . . . .	315.4	17°	301	The barometer at Portici was 7 toises above the level of the Mediterranean; at the lower brink of the crater, the instrument was placed lower than the 29th of July.
at 45 minutes past 5	Beginning of the cone . . . . .	311.0	17.5	365	
at 7	Hill in the centre of the crater . . . . .	298.5	15	542	
at 8	Lowest brink of the crater . . . . .	300.7	15.5	511	
at $\frac{1}{2}$ past 3	Portici . . . . .	337.0	16		
at 2 in the afternoon	Idem . . . . .	337.0	24		

1797. Having reached half the height of the cone, he had a fall, and rolled down as far as the small plain of Rambleta ; happily a heap of lava, covered with snow, hindered him from rolling farther with accelerated velocity. I have been told, that in Switzerland, a traveller was suffocated by rolling down the declivity of the Col de Balme, over the compact turf of the Alps.

When we gained the summit of the Piton, we were surprised to find scarcely room enough to seat ourselves conveniently. We were stopped by a small circular wall of porphyritic lava, with base of pitchstone, which concealed from us the view of the crater \*. The west wind blew with such violence that we could scarcely stand. It was eight in the morning, and we were frozen with the cold, though the thermometer kept a little above the freezing point. For a long time

Mr. de la Jumélière asserts, in a paper printed in the *Moniteur*, that he found, by geometrical measurement, the height of Vesuvius 597 toises. It were to be wished, that he had published the detail of his operations. Our measurements give 606 toises (1181 metres) for the most elevated brink of the crater ; 535 toises (1042 metres) for the lower brink ; 370 toises (721 metres) for the foot of the cone of ashes ; and 302 toises (588 metres) for the hermitage of San Salvador. Such was the state of Vesuvius a short time before the eruption in the year 1805, in which the lava made a breach in the brink of the crater on the side of Torre del Greco.

\* *La Caldera*, or the *caldron* of the Peak, a denomination which recalls to mind the *Oules* of the Pyrenees. Ramond, *Voy. au Mont-Perdu*, p. 235.

we had been accustomed to a very high temperature, and the dry wind increased the feeling of cold, because it carried off every moment the small atmosphere of warm and humid air, which was formed around us from the effect of cutaneous perspiration.

The brink of the crater of the Peak bears no resemblance to those of the greater part of the other volcanoes which I have visited: for instance, the craters of Vesuvius, Jorullo, and Pichincha. In these the Piton preserves it's conic figure to the very summit; the whole of their declivity is inclined the same number of degrees, and uniformly covered with a layer of pumice stone very minutely divided; when we reach the top of these volcanoes nothing obstructs the view of the bottom of the crater. The Peak of Teneriffe, and Cotopaxi, on the contrary, are of very different construction. At their summit a circular wall surrounds the crater; which wall, at a distance, has the appearance of a small cylinder placed on a truncated cone. On Cotopaxi\* this peculiar construction is visible to the naked eye at more than 2000 toises distance; and no person has ever reached the crater of this volcano. On the Peak of Teneriffe, the wall, which surrounds the crater like a parapet, is so high, that it would be impossible to reach the Caldera, if on the eastern side there was not a

\* Picturesque Atlas, folio, pl. 10.



breach, which seems to have been the effect of a flowing of very old lava. We descended through this breach toward the bottom of the funnel, the figure of which is elliptic. It's greater axis has a direction from north-west to south-east, nearly N.  $35^{\circ}$  W. The greatest breadth of the mouth appeared to us to be 300 feet, the smallest 200 feet. These numbers agree very nearly with the measures of Messrs. Verguin, Varela, and Borda \*, for these travellers assign 40 and 30 toises to the two axes †.

It is easy to conceive, that the size of a crater does not depend solely on the height and mass of the mountain, of which it forms the principal air vent. This opening is indeed seldom in direct ratio with the intensity of the volcanic fire, or with the activity of the volcano. At Vesuvius, which is but a hill compared with the Peak of Teneriffe, the diameter of the crater is five times greater. When we reflect, that very lofty volcanoes throw out less matter by their summits, than by lateral openings, we should be led to think, that the lower the volcanoes are, their force and activity being the same, the more

\* Voy. de la Flore, t. i, p. 94. Manusc. du Dépôt de la Marine, cah. 7, p. 15. Voy. de Marchand, t. ii, p. 11.

† Mr. Cordier, who visited the top of the Peak four years after me, estimates the greater axis at 66 toises (Journ. de Phys. t. lvii. p. 62). Lamanon thinks it 50 toises. But Mr. O'Donnel gives the crater a circumference of 236 toises (550 *varas*).

considerable ought to be their craters. In fact, there are immense volcanoes in the Andes, which have but very small openings; and we might establish it as a geological principle, that the most colossal mountains have craters of little extent at the summits, if the Cordilleras did not offer many instances\* to the contrary. I shall have occasion, in the progress of this work, to cite a number of facts, which will throw some light on what may be called the external structure of volcanoes. This structure is as varied as the volcanic phenomena themselves: and in order to raise ourselves to geological conceptions worthy of the greatness of nature, we must set aside the idea, that all volcanoes are formed after the model of Vesuvius, Stromboli, and Etna.

The external edges of the Caldera are almost perpendicular. Their appearance is somewhat like the Somma, seen from the Atrio del Cavallo. We descended to the bottom of the crater on a train of broken lava, from the eastern breach of the enclosure. The heat was perceptible only in a few crevices, which gave vent to aqueous vapours with a peculiar buzzing noise. Some of these funnels or crevices are on the outside of the enclosure, on the external brink of the para-

\* The great volcanoes of Cotopaxi and Rucupichincha have craters, the diameter of which, according to my measurements, exceed 400 and 700 toises.

pet that surrounds the crater. We plunged the thermometer into them, and saw it rise rapidly to 68 and 75 degrees. It no doubt indicated a higher temperature, but we could not observe the instrument till we had drawn it up, lest we should burn our hands. M. Cordier found several crevices, the heat of which was that of boiling water. It might be thought, that these vapours, which are emitted in gusts, contain muriatic or sulphurous acid; but when condensed, they have no particular taste; and experiments, which several naturalists\* have made with reagents, prove, that the chimneys of the Peak exhale only pure water. This phenomenon, analogous to what I observed in the crater of Jorullo, deserves the more attention, as muriatic acid abounds in the greater part of volcanoes, and as Mr. Vauquelin has discovered it even in the porphyritic lavas of Sarcouy in Auvergne.

I sketched on the spot a view † of the interior edge of the crater, as it presented itself in the descent by the eastern break. Nothing is more striking than the manner, in which these strata of lavas are piled on one another, exhibiting the sinuosities of the calcareous rock of the higher Alps. These enormous ledges, sometimes horizontal, at others inclined and undulating, remind

\* Voyage de La Pérouse, t. iii, p. 2.

† Picturesque Atlas, folio, Pl. 54.

us of the ancient fluidity of the whole mass, and the combination of several deranging causes, which determined the direction of each flow. The top of the circular wall exhibits those grotesque ramifications which we find in coak. The northern edge is more elevated; towards the south-east, the enclosure is considerably sunk, and an enormous mass of scorious lava seems glued to the extremity of the brink. On the west the rock is perforated; and a large opening gives a view of the horizon of the sea. The force of the elastic vapours formed perhaps this natural aperture, at the moment of some inundation of lava thrown out from the crater.

The inside of this funnel indicates a volcano, which for thousands of years has vomited no fire but by it's sides. This assertion is not founded on the absence of great openings, which might be expected in the bottom of the Caldera. Those naturalists, who have studied nature on the spot, know, that several volcanoes, in the intervals of an eruption, appear filled up, and almost extinguished; but that in these same mountains, the crater of the volcano exhibits layers of scorïæ, rough, sonorous, and shining; with hillocks and intumescences, caused by the action of the elastic vapours, cones of broken scorïæ, and ashes, which cover the funnels. None of these phenomena characterise the crater of the Peak of Teneriffe; it's bottom has not remained in the state

which follows the end of an eruption. From the lapse of time, and the action of the vapors, the inside walls are detached, and have covered the basin with great blocks of lithoid lavas.

We reached the bottom of the Caldera without danger. In a volcano, the activity of which is principally directed towards the summit, such as Vesuvius, the depth of the crater varies before and after each eruption; but at the Peak of Teneriffe, the depth appears to have remained the same for a long time. Eden, in 1715, estimated it at 115 feet; Cordier, in 1803, at 110 feet. Judging by mere inspection, I should have thought the funnel of still less depth. It's present state is that of a solfatara; and it is rather an object of curious investigation, than of tremendous aspect. The majesty of the site consists in it's elevation above the level of the ocean, in the profound solitude of these lofty regions, and the immense space over which the eye ranges from the summit of the mountain.

The wall of compact lava which forms the enclosure of the Caldera, is snow white at it's surface. The same colour prevails in the inside of the solfatara of Puzzuoli. When we break these lavas, which might be taken at some distance for calcareous stone, we find in them a blackish brown nucleus. Porphyry with basis of pitch stone is whitened externally by the slow action of the vapors of sulphurous acid gas.



These vapors rise in abundance; and, what is remarkable enough, through crevices which seem to have no communication with the apertures that emit aqueous vapors. We may be convinced of the presence of the sulphurous acid, by examining the fine crystals of sulphur, which are every where found in the crevices of the lava. This acid, combined with the water with which the soil is impregnated, is transformed into sulphuric acid by contact with the oxygen of the atmosphere. In general, the humidity in the crater of the Peak is more to be feared than the heat; and they who seat themselves for a while on the ground find their clothes corroded. The porphyritic lavas are affected by the action of the sulphuric acid: the alumin, magnesia, soda, and metallic oxids, gradually disappear; and often nothing remains but the silex, which unites in mammillary plates, like opal. These siliceous concretions\*, which Mr. Cordier first made known, are similar to those found in the Isle of Ischia, in the extinguished volcanoes of Santa Fiora, and in the Solfatara of Puzzuoli †. It is not easy to form an idea of the origin of these

\* *Opalartiger kieselsinster*. The siliceous *guruh* of the volcanoes of the Isle of France contains, according to Klaproth, 0·72 silex, and 0·21 water; and thus comes near to opal, which Karsten considers as a hydrated silex. *Miner Tabellen*, 1800, p. 70.

† Breislak, *Introduzione alla Geologia*, t. ii, p. 238.

incrustations. The aqueous vapors, discharged through great spiracles, do not contain alkali in solution, like the waters of the Geyser, in Iceland \*. Perhaps the soda contained in the lavas of the Peak acts an important part in the formation in these depositions of silex. There may exist in the crater small crevices, the vapors of which are not of the same nature as those on which travellers, employed at the same moment in a great number of objects, have made experiments.

Seated on the northern brink of the crater, I dug a hole of some inches depth; the thermometer placed in this hole rose rapidly to 42°. Hence we may conclude what must be the heat, that reigns in this solfatara at the depth of thirty or forty fathoms. The sulphur reduced into vapour is condensed into fine crystals, which however are not equal in size to those Mr. Dolomieu brought from Sicily †. They are semidiaphanous octaedrons, with very brilliant surfaces, and of a conchoidal fracture. These masses, which will one day perhaps be objects of commerce, are constantly bedewed with sulphurous acid. I had the imprudence to wrap up a few, in order to preserve them, but I soon discovered, that the acid had consumed not only the paper which

\* Black. in Philos. Transact. 1794, p. 24.

† These crystals were four or five inches in length. Drée, Cat. d'un Musée minéral. p. 21.

contained them, but a part also of my mineralogical journal. The heat of the vapors, which issue from the crevices of the Caldera, is not sufficiently great, to combine the sulphur, while in a state of minute division, with the oxygen of the atmospheric air; and after the experiment which I have just cited on the temperature of the soil, we may presume, that the sulphurous acid is formed at a certain depth \*, in cavities to which the external air has free access.

The vapors of heated water, which act on the fragments of lava scattered about on the Caldera, reduce certain parts of it to a state of paste. On examining, after I had reached America, those earthy and friable masses, I found crystals of sulphat of alumin. Messrs. Davy and Gay-Lussac † have already made the ingenious remark, that two bodies highly inflammable, the metals of soda and potash, have probably an important part in the action of a volcano; now the

\* An observer, in general very exact, Mr. Breislack, asserts (*Geologia*, t. ii, p. 232), that the muriatic acid always predominates in the vapours of Vesuvius. This assertion is contrary to what Mr. Gay-Lussac and myself observed, before the great eruption of 1805, and while the lava was issuing from the crater. The smell of the sulphurous acid, so easy to distinguish, was perceptible at a great distance; and when the volcano threw out scorïæ, the smell was mingled with that of petroleum.

† Davy, on the Decomposition of fixed Alkalies, *Phil. Trans.* 1808, P. 1, p. 44.

potash necessary to the formation of alum is found not only in feldspar, mica, pumice stone, and augit, but also in obsidians \*. This last substance is very common at Teneriffe, where it forms the basis of the tephritic lava †. These analogies between the Peak of Teneriffe and the Solfatara of Puzzuoli, would no doubt appear more numerous, if the former were more accessible, and had been frequently visited by naturalists.

An expedition to the summit of the volcano of Teneriffe, is interesting, not solely on account of the great number of phenomena which are the objects of scientific research ; it has still greater attractions from the picturesque beauties, which it lays open to those who are feelingly alive to the majesty of nature. It is a difficult task, to describe those sensations, which act with so much the more force as they have something undefined, produced by the immensity of the space as well as by the greatness, the novelty, and the multitude of the objects, amidst which we find ourselves transported. When a traveller attempts to furnish descriptions of the loftiest summits of the globe, the cataracts of the great rivers, the tortuous vallies of the Andes, he is

\* Collet Descotils, in the *Ann. de Chimie*, t. liii, p. 260. See Klaproth, *Beitrag*, B. 5, p. 159, 162, and 166.

† Laméthiere, *Minéralogie*, t. ii, p. 533 ; and *Journal de Physique*, 1806, p. 192.

exposed to the danger of fatiguing his readers by the monotonous expression of his admiration. It appears to me more conformable to the plan, which I have proposed to myself in this narrative, to indicate the peculiar character that distinguishes each zone; we exhibit with more clearness the physiognomy of the landscape, in proportion as we endeavour to sketch it's individual features, to compare them with each other, and discover by this kind of analysis the sources of those enjoyments, which are offered us by the great picture of nature.

Travellers have learnt by experience, that views from the summits of very lofty mountains are neither so beautiful, picturesque, nor varied, as those from heights which do not exceed that of Vesuvius, Rigi, and the Puy-de-Dôme. Colossal mountains, such as Chimborazo, Antisana, or Mount Rose, compose so large a mass, that the plains covered with rich vegetation are seen only in the immensity of distance, where a blue and vapory tint is uniformly spread over the landscape. The Peak of Teneriffe, from it's slender form and local position, unites the advantages of less lofty summits to those which arise from very great heights. We not only discover from it's top a vast expanse of sea, but we see also the forests of Teneriffe, and the inhabited parts of the coasts, in a proximity fitted to produce the most beautiful contrasts of form and



colour. We might say, that the volcano crushes with it's mass the little isle which serves as it's basis, and shoots up from the bosom of the waters to a height three times loftier than the region where the clouds float in the summer. If it's crater, half extinguished for ages past, shot forth flakes of fire like that of Stromboli in the Æolian islands, the Peak of Teneriffe, resembling a lighthouse, would furnish a direction to the mariner in a circuit of more than 260 leagues.

When seated on the external edge of the crater, we turned our eyes towards the north-west, where the coasts are decked with villages and hamlets. At our feet, masses of vapour, constantly driven by the winds, afforded us the most variable spectacle. A uniform stratum of clouds, the same as we have just described, and which separated us from the lower regions of the island, had been pierced in several places by the effect of the small currents of air, which the earth, heated by the sun, began to send towards us. The port of Orotava, it's vessels at anchor, the gardens and the vineyards which encircle the town, exhibited themselves through an opening which seemed to enlarge every instant. From the summit of these solitary regions our eyes hovered over an inhabited world; we enjoyed the striking contrast between the bare sides of the Peak, it's steep declivities covered with scorïæ, it's elevated plains destitute of vegetation,

and the smiling aspect of the cultured country beneath ; we beheld the plants divided by zones, as the temperature of the atmosphere diminished with the height of the site. Below the Piton, lichens begin to cover the scorious lava with lustered surface ; a violet \*, akin to the *viola decumbens*, rises on the slope of the volcano at 1740 toises of height ; it takes the lead not only of the other herbaceous plants, but even of the *gramina*, which, in the Alps and on the ridge of the Cordilleras, form close neighbourhood with the plants of the family of *cryptogamia*. Tufts of *retama*, loaded with flowers, make gay the valleys hollowed out by the torrents, and which are encumbered with the effects of the lateral eruptions ; below the *spartium*, or *retama*, lies the region of ferns, bordered by the tract of the arborescent heaths. Forests of *laurel*, *rhamnus*, and *arbutus*, divide the *ericas* from the rising grounds planted with vines and fruit trees. A rich carpet of verdure extends from the plain of *spartium*, and the zone of the alpine plants even to the group of the date trees and the *musa*, at the feet of which the ocean appears to roll. I here pass slightly over the principal features of this botanical chart, as I shall enter hereafter into some farther details respecting the geography of the plants of the Isle of Teneriffe.

\* *Viola cheiranthifolia*. See our equinoctial plants, vol. i, p. 111, Pl. 32.

The seeming proximity, in which, from the summit of the Peak, we behold the hamlets, the vineyards, the gardens on the coast, is increased by the prodigious transparency of the atmosphere. Notwithstanding the great distance, we distinguished not only the houses, the sails of the vessels, and the trunks of trees, our eyes dwelt on the rich vegetation of the plains, enamelled with the most vivid colouring. These phenomena are owing not only to the height of the site, but to the peculiar modifications of the air in warm climates. Under every zone, an object placed on a level with the sea, and viewed in a horizontal direction, appears less luminous, than when seen from the top of a mountain, where vapors arrive across strata of air of decreasing density. Differences equally striking are produced by the influence of climates; the surface of a lake or large river is less resplendent, when we see it at an equal distance, from the top of the higher Alps of Switzerland, than when we view it from the summit of the Cordilleras of Peru or Mexico. In proportion as the air is pure and serene, the solution of the vapors becomes more perfect, and the light loses less in its passage. When from the coast of the South Sea we reach the elevated plain of Quito, or that of Antisana, we are struck for some days at the nearness at which we think we see objects which are seven or eight leagues distant. The Peak of

Teyde has not the advantage of being situate in the equinoctial region ; but the dryness of the columns of air which rise perpetually above the neighbouring plains of Africa, and which the eastern winds bring with rapidity, gives the atmosphere of the Canary Islands a transparency, which surpasses not only that of the air of Naples and Sicily, but perhaps also the purity of the sky of Quito and Peru. This transparency may be regarded as one of the chief causes of the beauty of the landscape under the torrid zone ; it is this which heightens the splendor of the vegetable coloring, and contributes to the magical effect of their harmonies and their contrasts. If a mass of light, which circulates about objects, fatigues the external senses during a part of the day, the inhabitant of the southern climates has his compensations in moral enjoyments. A lucid clearness in the conceptions, a serenity of mind, correspond with the transparency of the surrounding atmosphere. We feel these impressions without overstepping the limits of Europe. I appeal to travellers who have visited countries rendered famous by prodigies of the imagination and the arts, the favoured climates of Italy and Greece.

We prolonged in vain our stay on the summit of the Peak, to wait the moment when we might enjoy the view of the whole of the Archipelago of

the Fortunate Islands \*. We discovered Palma, Gomera, and the Great Canary, at our feet. The mountains of Lanzerota, free from vapors at sunrise, were soon enveloped in thick clouds. On a supposition only of an ordinary refraction, the eye takes in, in calm weather, from the summit of the volcano, a surface of the globe of 5700 square leagues, equal to a fourth of the surface of Spain. The question has often been agitated, if it were possible to perceive the coast of Africa from the top of this colossal pyramid ; but the nearest parts of this coast are still farther from Teneriffe than  $2^{\circ} 49'$ , or 56 leagues. The visual ray of the horizon from the Peak, being  $1^{\circ} 57'$ , Cape Bojador can be seen only on the supposition of it's height being 200 toises above the level of the ocean. We are absolutely ignorant of the height of the Black Mountains near Cape Bojador, as well as that of the Peak, called by navigators *Pennon grande*, farther to the south of this promontory. If the summit of the volcano of Teneriffe was more accessible, we should observe without doubt, with certain winds, the effects of an extraordinary refraction. In look-

\* Of all the small islands of the Canaries, the *Rock of the East* is the only one, which cannot be seen, even in fine weather, from the top of the Peak. It's distance is  $3^{\circ} 5'$ , while that of the Salvage is only  $2^{\circ} 1'$ . The Isle of Madeira, distant  $4^{\circ} 29'$ , would be visible, if it's mountains were more than 3000 toises high.



ing over what the Spanish and Portuguese authors relate respecting the existence of the fabulous isle of San Borondon, or Antilia, we find, that it is particularly the humid wind of the west-south-west, which produces in these latitudes the phenomena of the mirage. We shall not however admit with Mr. Vieyra, "that the play of the terrestrial refractions \*, may render visible to the inhabitants of the Canaries the islands of Cape Verd, and even the Apalachian Mountains of America."

The cold, which we felt on the top of the Peak, was very considerable for the season. The centigrade thermometer †, at a distance from the ground, and from the apertures that emitted the hot vapors, descended in the shade to  $2\cdot7^{\circ}$ . The wind was west, and consequently opposite to

\* "La refraction da para todo." Noticias historicas, t. i, p. 105. We have already stated, that the American fruits, frequently thrown by the sea on the coasts of the isles of Ferro and Gomera, were formerly attributed to the plants of the island of San Borondon. This land, said by the people to be governed by an archbishop and six bishops, and which Father Feijoo believed to be the image of the isle of Ferro, reflected on a fog bank, was ceded in the 16th century, by the king of Portugal, to Lewis Perdigon, at the time the latter was preparing to make the conquest of it.

† Messrs. O'Donnel and Armstrong observed the 2d of August, 1806, at eight in the morning, on the top of the Peak, the thermometer in the shade at  $13\cdot8^{\circ}$ , and in the sun at  $20\cdot5^{\circ}$ . Difference or power of the sun  $6\cdot7$  centesimal degrees.

that which brings to Teneriffe, during a great part of the year, the warm air, that rises above the burning desert of Africa. As the temperature of the atmosphere, observed at the port of Orotava by Mr. Savagi, was  $22.8^{\circ}$ , the decrement of caloric was one degree every 94 toises. This result perfectly corresponds with those obtained by Lamanon and Saussure\* on the summits of the Peak and Etna, though in very different seasons. The tall slender form of these mountains facilitates the means of comparing the temperature of two strata of the atmosphere, which are nearly in the same perpendicular plane; and under this point of view the observations made in an excursion to the volcano of Teneriffe, resemble those of an ascent in a balloon. We must nevertheless remark, that the ocean, on account of it's transparency and evaporation, reflects less caloric than the plains into the upper regions of the air; the summits also which are surrounded by the sea are colder in the summer, than the mountains which rise from a continent; but this circumstance has very little influence on the decrement of the atmospherical heat, the temperature of the low regions being equally diminished by the proximity of the ocean.

\* The observations of Lamanon give 99 toises for each degree of the centigrade thermometer, though the temperature of the Piton differed  $9^{\circ}$  from that which we observed. At Etna the decrement observed by Saussure was 91 toises.

It is not the same with respect to the influence exercised by the direction of the wind, and the rapidity of the ascending current; the latter sometimes increases in an astonishing manner the temperature of the loftiest mountains. I have seen the thermometer rise, on the slope of the volcano of Antisana, in the kingdom of Quito, to  $19^{\circ}$ , when we were 2837 toises high. Mr. Labillardière\* has seen it remain, on the edge of the crater of the Peak of Teneriffe, at  $18.7^{\circ}$ , though he had used every possible precaution to avoid the effect of accidental causes. The temperature of the road of Santa Cruz being then at  $28^{\circ}$ , the difference between the air of the coast and on the summit of the Peak was  $9.3^{\circ}$ , instead of  $20^{\circ}$ , which corresponds to a decrement of caloric of 94 toises to each degree. I find in the Journal of the Expedition of d'Entrecasteaux, that at this period the wind at Santa Cruz was south-south-east. This same wind blew perhaps more impetuously in the higher regions of the atmosphere, and forced back, in an oblique direction, the hot air of the neighbouring continent toward the summit of the Piton. Besides, the visit of Mr. Labillardière took place on the 17th of October 1791; and, in the Alps of Switzerland, we have observed, that the difference of temperature between the mountains and the

\* Voyage à la Recherche de La Pérouse, vol. i, p. 23; vol. ii, p. 65.

plains is considerably less in autumn, than in summer. All these variations \* of the rapidity, with which caloric decreases, have their influence on the measures taken by the barometer, only in as much as the decrement is not uniform in the intermediate strata, and as it differs from the arithmetical or harmonic progression, which is presumed in the formulæ employed.

We could not withdraw our eyes, on the summit of the Peak, from beholding the color of the azure vault of the sky. It's intensity at the zenith appeared to correspond to  $41^{\circ}$  of the cyanometer. We know by Saussure's experiment, that this intensity increases with the rarity of the air, and that the same instrument indicated

\* I shall here bring into one point of view the whole of the thermometrical observations made at the Peak of Teneriffe, and which are proper to determine the number of toises, that correspond to a lowering of a centigrade degree :

1° Borda (month of September.)

- To the Pino de Dornajito, 104 toises (morning) ;
- To the Station of the Rocks, 107 toises (evening) ;
- To the natural icehouse, 105 toises (morning) ;
- To the foot of the Piton, 151 toises (morning) ;
- To the top of the Peak, 137 toises (morning) ;

2° Lamanon (month of August),

- To the top, 99 toises (morning) ;

3° Cordier (month of April),

- To the Station of the Rocks, 122 toises (evening) ;
- To the top, 115 toises (morning) ;

4° Our Voyage (month of June),

- To the top, 94 toises.

at the same period  $20^{\circ}$  at the priory of Chamouni, and  $40^{\circ}$  at the top of Mont-Blanc. This last mountain is 540 toises higher than the volcano of Teneriffe; and if, notwithstanding this difference, the sky is seen there of a less deep blue, we must attribute this phenomenon to the dryness of the African air, and the proximity of the torrid zone.

We collected air on the brink of the crater, which we meant to analyse on our voyage to America. The phial remained so well corked, that, on opening it ten days after, the water rushed in with impetuosity. Several experiments, made by means of nitrous gas in the narrow tube of Fontana's eudiometer, seemed to prove, that the air of the crater contained 0.09 less oxygen than the air of the sea; but I have little confidence in this result obtained by means which we now consider as very inexact. The crater of the Peak has so little depth, and the air is renewed with so much facility, it is scarcely probable, that the quantity of azot is greater there than on the coasts. We knew also, from the experiments of Messrs. Gay-Lussac and Theodore de Saussure, that in the highest as well as in the lowest regions of the atmosphere, the air equally contains 0.21 of oxygen \*.

\* During the stay Messrs. Gay-Lussac and myself made at the hospice of Mount Cenis, in March, 1805, we collected air in the midst of a strongly electrified cloud. This air,



We saw on the summit of the Peak no trace of psora, leciea, or other cryptogamous plants : no insect fluttered in the air. We found however a few hymenopteras adhering to masses of sulphur moistened with sulphurous acid, and lining the mouths of the funnels. These are bees, which appear to have been attracted by the flowers of the spartium nubigenum, and which oblique currents of air had carried up to these high regions, like the butterflies found by Mr. Ramond at the top of Mont Perdu. The butterflies perished from cold, while the bees on the Peak were scorched on imprudently approaching the crevices where they came in search of warmth.

Notwithstanding the heat we felt in our feet on the edge of the crater, the cone of ashes remains covered with snow during several months in the winter. It is probable, that under the cap of snow considerable hollows are found, like those we find under the glaciers of Switzerland, the temperature of which is constantly less elevated than that of the soil on which they repose \*. The cold and violent wind, which blew

analysed in Volta's eudiometer, contained no hydrogen, and its purity did not differ 0.002 of oxygen from the air of Paris, which we had carried with us in phials hermetically sealed. On air collected at 3405 toises height, see *Annal. de Chimie*, t. lii, p. 92.

\* See the excellent work of Mr. Stapfer, *Voy. Pittoresq. de l'Oberland*, p. 61.

from the time of sunrise, engaged us to seek shelter at the foot of the Piton. Our hands and faces were frozen, while our boots were burnt by the soil on which we walked. We descended in the space of a few minutes the Sugar Loaf which we had scaled with so much toil; and this rapidity was in part involuntary, for we often rolled down on the ashes. It was with regret that we quitted this solitary place, this domain where Nature towers in all her majesty; we soothed ourselves with the hope of once again visiting the Canary islands; but this, like many other plans which we then formed, has never been executed.

We traversed the Malpays but slowly; the foot finds no sure foundation on loose blocks of lava. Nearer the Station of the Rocks, the descent becomes extremely painful; the compact short-swarded turf is so slippery, that we were obliged to incline our bodies continually backward, in order to prevent our falling. In the sandy plain of Retama, the thermometer rose to  $22.5^{\circ}$ ; and this heat seemed to us suffocating in comparison with the sensation of cold, which we had suffered from the air on the summit of the volcano. We were absolutely without water; our guides, not satisfied with drinking clandestinely the little provision of malmsey, for which we were indebted to Mr. Cologan's careful kindness, had broken our water vessels. Happily

the bottle which contained the air of the crater escaped unhurt.

We at length enjoyed the refreshing breeze in the beautiful region of the arborescent erica and fern; we were enveloped in a thick bed of clouds stationary at six hundred toises above the plain. In crossing this, we remarked a phenomenon which was afterwards familiar to us on the declivities of the Cordilleras. Small currents of air chased trains of clouds with unequal velocity, and in opposite directions; and bore the appearance of streamlets of water in rapid motion and in all directions, amidst a great mass of stagnant waters. The causes of this partial motion of the clouds are probably very various; we may suppose it to arise from some impulsion at a great distance; from the slight inequalities of the soil, which reflects, in a greater or less degree the radiant heat; from a difference of temperature kept up by some chemical action; or perhaps from a strong electric charge of the vesicular vapors.

As we approached the town of Orotava, we met great flocks of canaries\*. These birds, well known in Europe, were in general uniformly green; some had a yellow tint on their backs.

\* *Fringilla canaria*. La Caille relates, in the narrative of his voyage to the Cape, that on Salvage island these canaries are so abundant, you cannot walk there in a certain season without breaking their eggs.

their note was the same as that of the tame canary. It is nevertheless remarked, that those which have been taken in the isle of the Great Canary, and in the islet of Monte Clara, near Lanzerota, have a stronger, and at the same time the most harmonious song. Under every zone, among birds of the same species, each flock has it's peculiar note. The yellow canaries are a variety which has taken birth in Europe; and those we saw in cages at Orotava and Santa Cruz had been bought at Cadiz, and in other ports of Spain. But of all the birds of the Canary islands, that which has the most heartsoothing song is unknown in Europe; this is the capirote, which no effort has been able to tame, so sacred to his soul is liberty. I have stood in admiration of his soft and melodious warbling, in a garden at Orotava; but I have never seen him sufficiently near, to know to what family he belongs. As to the parrots, which were supposed to have been seen at the period of Captain Cook's abode at Teneriffe, they never existed but in the narrative of a few travellers, who have copied from each other. Neither parrots nor monkeys inhabit the islands of the Canaries; and though in the New Continent the former migrate as far as North Carolina, I doubt whether in the Old they have ever been met with beyond the 28th degree of north latitude.

Toward the close of day we reached the port



of Orotava, where we heard the unexpected news, that the Pizarro would not set sail till the 24th or 25th. If we could have calculated on this delay, we should either have lengthened our stay\* on the Peak, or made an excursion to the volcano of Chahorra. We passed the following day in visiting the environs of Orotava, and enjoying the agreeable company we found at Mr. Cologan's. We perceived, that the abode at Teneriffe was interesting not only to those whose business is the study of nature; we found at Orotava several persons, who have a taste for literature and music, and who have transplanted into these distant climates the amenity of European society. In these respects, the Canary islands have no great resemblance to the other Spanish colonies, excepting the Havannah.

We were present, the eve of St. John, at a

\* As a great number of travellers, who land at Santa Cruz, do not undertake the excursion to the Peak, because they are ignorant of the time which it takes, it may be useful to lay down the following data: In making use of mules as far as the Station of the English, it takes twenty-one hours from Orotava to arrive at the summit of the Peak, and return to the port; namely, from Orotava to the Pino del Dornajito three hours; from the Pino to the Station of the Rocks six hours; and from this station to the Caldera three hours and a-half. I reckon nine hours for the descent. In this valuation I count only the time employed in walking, and no way that which is necessary to examine the productions of the Peak, or to take repose. Half a day is sufficient to go from Santa Cruz to Orotava.



pastoral fête in the garden of Mr. Little. This gentleman, who had rendered great service to the Canarians during the last famine, has cultivated a hill covered with volcanic substances. He has formed in this delicious site an English garden, whence there is a magnificent view of the Peak, of the villages along the coast, and the isle of Palma, which limits the vast extent of the ocean. I cannot compare this prospect with any, except those of the bays of Genoa and Naples ; but Orotava is greatly superior to both in the magnitude of the masses, and in the richness of vegetation. In the beginning of the evening, the slope of the volcano exhibited on a sudden a most extraordinary spectacle. The shepherds, in conformity to a custom, no doubt introduced by the Spaniards, though it dates from the highest antiquity, had lighted the fires of St. John. These scattered masses of fire, these columns of smoke driven by the wind, formed a fine contrast with the deep verdure of the forests, which covered the sides of the Peak. Shouts of joy heard from afar were the only sounds, that broke the silence of nature in these solitary abodes.

Mr. Cologan's family has a country house nearer the coast than that I have just mentioned. The name given by the proprietor is appropriate to the sentiment, which this rural spot inspires. The house of *La Paz* was also connect-

ed with the circumstance that rendered it peculiarly interesting to us. Mr. de Borda, whose death we deplored, was it's inmate during his last visit to the Canary islands. It was in a small neighbouring plain, that this gentleman measured the base, by which he determined the height of the Peak. In this geometrical operation, the great dracœna of Orotava served as a mark. If any well-informed traveller should some future day undertake a new measurement of the volcano with more exactness, and by means of astronomical repeating circles, he ought to measure the base, not near Orotava, but near *Silos*, at a place called *Bante*. According to Mr. Broussonet, there is no plain near the Peak of greater extent. In herbalizing near La Paz, we found a great quantity of lichen roccella on the basaltic rocks bathed by the waters of the sea. The archil of the Canaries is a very ancient branch of commerce; this lichen is however found in less abundance in the isle of Teneriffe, than in the desert islands of Salvage, La Graciosa, and L'Alegranza, or even in Canary and Hierro.

We left the port of Orotava on the 24th of June in the morning: we dined, as we passed through Laguna, with the French consul. He had the kindness to take charge of the geological collections\* we had made, and which we

\* Mr. Hergen has described them in the *Annales de Ciencias naturales*, which he published jointly with Abbé Cavanilles.

destined for the king of Spain's cabinet of natural history. As we left the town, and turned our eyes toward the road of Santa Cruz, we were alarmed at seeing our vessel, the Pizzaro, under way. On reaching the port, we learnt, that she was plying under an easy sail, to wait for us. The English vessels, that were stationed off the island of Teneriffe, had disappeared: and we had not a moment to lose to go on board. We embarked alone, for our fellow-travellers were Canarians, and at the end of their journey. We regretted in this number Don Francisco Salcedo, son of the late Spanish governor of Louisiana, whom we met with again at the Isle of Cuba, on our return from the Oroonoko.

Not to interrupt the narrative of the excursion to the top of the Peak, I have said nothing of the geological observations I made on the structure of this colossal mountain, and on the nature of the volcanic rocks of which it is composed. Before we quit the Archipelago of the Canaries, I shall delay a moment, and bring into one point of view what relates to the physical picture of these countries.

The mineralogists who think, that the end of the geology of volcanoes is the classification of lavas, the examination of the crystals they contain, and their description according to their external characters, are generally very well satisfied, when they come back from the mouth of a burning volcano. They return loaded with nu-

merous collections, which are the principal objects of their researches. This is not the feeling of those, who, without confounding descriptive mineralogy\* with geognosy, endeavour to raise themselves to ideas generally interesting, and seek, in the study of nature, for answers to the following questions :

Is the conical mountain of a volcano entirely formed of liquified matter, heaped together by successive eruptions ; or does it contain in it's centre a nucléus of primitive rocks covered with lavas, which are these same rocks altered by fire ? What are the affinities, which unite the productions of modern volcanoes with the basalts, the phonolites, and those porphyries with basis of feldspar, which are without quartz, and which cover the Cordilleras of Peru and Mexico, as well as the small groups of the Monts d'Or, of Cantal, and of Mézen in France ? Has the central nucleus of volcanoes been heated in it's primitive position, and raised up, in a softened state, by the force of the elastic vapours, before these fluids communicated, by means of a crater, with the external air ? What is the substance, which, for thousands of years, keeps up this combustion, which is sometimes so slow, and at other times so active ? Does this unknown cause act at an immense depth ; or does this chemical action take place in secondary rocks lying on granite ?

The farther we are from finding a solution of



these problems in the numerous works hitherto published on Etna and Vesuvius, the greater is the desire of the traveller, to see with his own eyes. He hopes to be more fortunate than those who have preceded him; he wishes to form a precise idea of the geological relations, the volcano and the neighbouring mountains bear to each other; but how often is he disappointed, when, on the limits of the primitive soil, enormous banks of tufa and puzzolana render every observation on the position and stratification impossible! We reach the inside of the crater with less difficulty than we at first expected; we examine the cone from it's summit to it's basis; we are struck with the difference in the produce of each eruption, and with the analogy which still exists between the lavas of the same volcano: but, notwithstanding the care with which we interrogate nature, and the number of partial observations which are presented at every step, we return from the summit of a burning volcano less satisfied, than when we were preparing to go thither. It is after we have studied them on the spot, that the volcanic phenomena appear still more isolated, more variable, more obscure, than we figure them when consulting the narratives of travellers.

These reflections occurred to me on returning from the summit of the Peak of Teneriffe, the first unextinct volcano I had yet visited. They



returned anew, whenever in South America, or in Mexico, I had occasion to examine volcanic mountains. If we reflect on the little progress, which the labours of mineralogists, and the discoveries in chemistry, have made toward the knowledge of the physical geology of mountains, we cannot help being affected with a painful sentiment ; and this is felt still more strongly by those, who, questioning nature under different climates, are more occupied by the problems they have not been able to solve, than with the small number of results they have obtained.

The Peak of Ayadyrma, or of Echejde\*, is a conic and isolated mountain, placed in an islet of very small circumference. The learned, who do not take into consideration the whole surface of the Globe, believe, that these three circumstances are common to the greater part of volcanoes. They cite, in support of their opinion, Etna, the Peak of the Azores, the Solfatara of Guadaloupe, the Trois-Salazes of the Isle of Bourbon, and that archipelago of volcanoes contained in the Indian Sea and the Great Ocean. In Europe and in Asia, as far as the interior of the latter continent is known, no burning volcano is situate in a chain of mountains ; all being at a greater or less distance from these chains.

\* The word *Echejde*, which signifies *Hell* in the language of the Guanches, has been corrupted by the Europeans into Teyde.

In the New World, on the contrary, and this fact deserves the greatest attention, the volcanoes the most stupendous for their masses form a part of the Cordilleras themselves. The mountains of mica-slate and gneiss in Peru and New Grenada immediately touch the volcanic porphyries of the provinces of Quito and Pasto. To the south and north of these countries, in Chili and in the kingdom of Guatemala, the active volcanoes are grouped in rows. They are the continuation, as we may say, of the chains of primitive rocks; and if the volcanic fire has broken forth in some plain far from the Cordilleras, as in mount Sangay and Jorullo\*, we must consider this phenomenon as an exception to the law, which nature seems to have imposed on these regions. I here ought to state again these geological facts, because this pretended isolated situation of every volcano has been opposed to the idea, that the Peak of Teneriffe, and the other volcanic summits of the Canary Islands, are the remains of a submerged chain of mountains. The observations, which have been made on the grouping of the volcanoes in America, prove, that the ancient state of things represented in the *conjectural map of the Atlantic* by Mr. Bory de St. Vincent†, is no

\* Two volcanoes of the provinces of Quixos and Mechoacan, one in the southern, and the other in the northern hemisphere.

† The question, whether the traditions of the ancients re-

way in contradiction to the acknowledged laws of nature ; and that nothing opposes our admitting, that the summits of Porto Santo, Madeira, and the Fortunate Islands, may heretofore have formed, either a distinct range of primitive mountains, or the western extremity of the chain of Atlas.

The Peak of Teyde forms a pyramidal mass like Etna, Tungurahua, and Popocatepetl. This physiognomic character is very far from being common to all volcanoes. We have seen some in the southern hemisphere, which, instead of having the form of a cone or a bell, are lengthened in one direction, having the ridge sometimes smooth, and at others rough with small pointed rocks. This structure is peculiar to Antisana and Pichincha, two burning mountains of the province of Quito ; and the absence of the conic form ought never to be considered as a reason excluding a volcanic origin. I shall develop in the progress of this work some of the analogies, which I think I have perceived be-

pecting the Atlantis are founded on historical facts, is entirely different from this, whether the Archipelago of the Canaries and the adjacent islands are the wrecks of a chain of mountains, rent and sunk in the sea in one of the great convulsions of our Globe. I do not pretend to form any opinion in favour of the existence of the Atlantis; but I endeavour to prove, that the Canaries have no more been created by volcanoes, than the whole body of the smaller Antilles has been formed by madrepores.

tween the physiognomy of volcanoes and the antiquity of their rocks. It is here sufficient to observe in general, that the summits, which are still subject to eruptions of the greatest violence, and at the nearest periods to each other, are *slender peaks* of a conic form : that the mountains with *lengthened summits*, and rugged with small stony masses, are very old volcanoes, and near being extinguished ; and that rounded tops in the form of *domes*, or bells, indicate those problematic porphyries, which are supposed to have been heated in their primitive place, penetrated by vapors, and forced up in a softened state, without having ever flowed as real lithoidal lavas. To the first \* of these distinctions belong Coto-paxi, the Peak of Teneriffe, and that of Orizava in Mexico. The second † is common to Cargueirazo and Pichincha, in the province of Quito ; to the volcano of Puracey, near Popayan ; and perhaps also to Hecla, in Iceland. The third ‡ and last is found in the majestic figure of Chimborazo, and, if it be permitted to place by the side of this colossus a hill of Europe, in the Great Sarcouy in Auvergne.

In order to form a more exact idea of the external structure of volcanoes, it is important to compare their perpendicular height with their

\* Picturesque Atlas, folio, Pl. 10.

† Ibid, Pl. 61.

‡ Ibid, Pl. 16.



circumference. This however cannot be done with any exactness, unless the mountains are isolated, and placed on a plain which is nearly on a level with the sea. In calculating the circumference of the Peak of Teneriffe in a curve passing through the port of Orotava, Garachico, Adexe, and Guimar, and setting aside the prolongations of it's basis toward the forest of Laguna, and the north-east cape of the island, we find that this extent is more than 54000 toises. The height of the Peak is consequently one twenty-eighth of the circumference of it's basis. Mr. Von Buch found a thirty-third for Vesuvius; and which perhaps is less certain, a thirty-fourth for Etna\*. If the slope of these three volcanoes were uniform from the summit to it's basis, the Peak of Teyde would have an inclination of  $12^{\circ} 29'$ , Vesuvius  $12^{\circ} 41'$ , and Etna  $10^{\circ} 13'$ ; a result which must astonish those, who do not reflect on what constitutes an average slope. In a very

\* Gilbert, *Annalen der Physik*, B. 5, p. 455. Vesuvius is 133,000 palmas, or eighteen nautical miles in circumference. The horizontal distance from Resina to the crater is 3700 toises. Italian mineralogists have estimated the circumference of Etna at 840,000 palmas, or 119 miles. With these data, the ratio of the height to the circumference would be only a seventy-second; but I find on tracing a curve through Catania, Palermo, Bronte, and Piemonte, only 62 miles in circumference according to the best maps. This increases the ratio to a fifty-fourth. Does the basis fall on the outside of the curve that I assume?



long ascent, slopes of three or four degrees alternate with others which are inclined from 25 to 30 degrees; and the latter only strike our imagination, because we think all the slopes of mountains more steep than they really are. I may cite in support of this consideration the example of the ascent from the port of Vera Cruz to the elevated plain of Mexico. It is on the eastern slope of the Cordilleras that a road has been traced, which for ages has not been frequented except on foot, or on the back of mules. From Encero to the small Indian village of Las Vigas, there are 7500 toises of horizontal distance; and Encero being, according to my barometric measurement, 746 toises lower than Las Vigas, the result, for the mean slope, is only an angle of  $5^{\circ} 40'$ .

I have drawn on the same plate, the profiles of the Peak of Teneriffe, Cotopaxi, and Vesuvius. I could have wished to have substituted Etna for this last mountain, because it's form is more analogous to that of the two volcanoes of America and Africa; but I chose to trace only the outlines of mountains that I had visited and measured myself; and with respect to Etna I should have wanted data for the intermediary heights. I ought also to observe, that, in the three profiles, the scales of distances and of heights have the same proportions. The distances have been determined after the charts of

Zanoni, Borda, and La Condamine. The reader versed in the practice of levelling will not be astonished at the very gentle slope, which these profiles seem to indicate. In nature, an inclined plane of an angle of  $35^\circ$  appears to be  $50^\circ$ : we scarcely dare go down a hill of  $22^\circ$  slope in a carriage; and the parts of the volcanic cones, that are inclined  $40^\circ$  or  $42^\circ$ , are almost inaccessible, though the foot may form steps by plunging it in the ashes. I have recorded in a note\*

\* In places where there were at the same time slopes covered with tufted grass and loose sands I took the following measures :

- $5^\circ$ , slope already of a very marked inclination. In France the high roads must not exceed  $4^\circ 46'$  by law ;
- $15^\circ$ , slope extremely steep, and which we cannot descend in a carriage ;
- $37^\circ$ , slope almost inaccessible on foot, if the bottom be a naked rock, or a turf too thick to form steps. The body falls backwards when the tibia makes a smaller angle than  $53^\circ$ , with the sole of the foot;
- $42^\circ$ , the steepest slope that can be climbed on foot in a ground that is sandy, or covered with volcanic ashes,

When the slope is  $44^\circ$ , it is almost impossible to scale it, though the ground permits the forming of steps by thrusting in the foot. The cones of volcanoes have a medium slope from  $33^\circ$  to  $40^\circ$ . The steepest parts of these cones, either of Vesuvius, the Peak of Teneriffe, the volcano of Pichincha, or Jorullo, are from  $40^\circ$  to  $42^\circ$ . A slope of  $55^\circ$  is quite inaccessible. If seen from above it would be estimated at  $75^\circ$ .

the experiments I made on the difficulties arising from the declivities in mountainous countries.

Isolated volcanoes, in the most distant regions, are very analogous in their structure. At great elevations all have considerable plains, in the middle of which arises a cone perfectly circular. Thus at Cotopaxi the plains of Suniguaicu extend beyond the farm of Pansache. The stony summit of Antisana, covered with eternal snow, forms an islet in the midst of an immense plain, the surface of which is twelve leagues square, while it's height exceeds that of the Peak of Teneriffe two hundred toises. At Vesuvius, at three hundred and seventy toises high, the cone detaches itself from the plain of Atrio del Cavallo. The Peak of Teneriffe presents two of these elevated plains, the uppermost of which, at the foot of the Piton, is as high as Etna, and of very little extent ; while the lowermost, covered with tufts of retama (*spartium nubigenum*), reaches as far as the Estancia de los Ingleses. This rises above the level of the sea, almost as high as the city of Quito, and the summit of Mount Lebanon.

The greater the quantity of matter that has issued from the crater of a mountain, the more elevated is it's cone of ashes in proportion to the perpendicular height of the volcano itself. Nothing is more striking under this point of view, than the difference of structure between Vesu-

vius, the Peak of Teneriffe, and Pichincha. I have chosen this last volcano in preference, because it's summit \* enters scarcely within the limit of the perpetual snows. The cone of Cotopaxi, the form of which is the most elegant and most regular hitherto known, is 540 toises in height ; but it is impossible to decide, whether the whole of this mass is covered with ashes.

Names of the volcanoes.	Total height in toises.	Height of the cone covered with ashes.	Proportion of the cone to the total height.
Vesuvius	606	200	$\frac{1}{3}$
Peak of Teneriffe	1904	84	$\frac{1}{22}$
Pichincha	2490	240	$\frac{1}{10}$

This table seems to indicate, what we shall have an opportunity of proving more amply hereafter, that the Peak of Teneriffe belongs to that group of great volcanoes, which, like Etna and Antisana, have had more copious eruptions from their sides than from the summit. Thus the crater at the extremity of the Piton, which

\* I have measured the summit of Pichincha, that is the small mountain covered with ashes above the Llano del Vulcan, to the north of Alto de Chuquirá. This mount has not however the regular form of a cone. As to Vesuvius, I have indicated the mean height of the Sugar-Loaf, on account of the great difference between the two edges of the crater.

is called the Caldera, is extremely small; and this diminutiveness had already struck Mr. de Borda, and other travellers, who took little interest in geological investigations.

As to the nature of the rocks which compose the soil of Teneriffe, we must first distinguish between productions of the present volcano, and the range of basaltic mountains, which surround the Peak, and which do not rise more than five or six hundred toises above the level of the Ocean. Here, as well as in Italy, Mexico, and the Cordilleras of Quito, the rocks of trapp-formation\* are at a distance from the currents of recent lavas; every thing shows, that these two classes of substances, though they owe their origin to similar phenomena, date from very different periods. It is important to geology, not to confound the currents of modern lavas, the heaps of basalt, greenstone, and phonolite, which are dispersed over the primitive and secondary formations, with those porphyroid masses with basis of compact feldspar†, which

\* The *trapp-formation* includes the basalts, greenstone (*grunstein*), the trappean porphyries, the phonolites or *porphyrschiefer*, &c.

† These petrosiliceous masses contain vitreous and often calcined crystals of feldspar, of hornblende, of pyroxene, a little of olivine, but scarcely any quartz. To this very ambiguous formation belong the trappean porphyries of Chimborazo and of Riobamba in America, of the Euganean mountains in Italy, and of the Siebengebirge in Germany; as well



perhaps have never been perfectly liquified, but which do not less belong to the domain of volcanoes.

In the isle of Teneriffe strata of tufa, puzzolana, and clay, separate the range of basaltic hills from the currents of recent lithoid lavas, and from the eruptions of the present volcano. In the same manner as the eruptions of Epomeo in the isle of Ischia, and those of Jorullo in Mexico, have taken place in countries covered with trappean porphyry, ancient basalt, and volcanic ashes, so the Peak of Teyde has raised itself amidst the wrecks of submarine volcanoes. Notwithstanding the difference of composition in the recent lavas of the Peak, there is a certain regularity of position, which must strike the naturalist the least skilled in geognosy. The great elevated plain of Retama separates the black, basaltic, and earthlike lava, from the vitreous and feldsparry lava, the basis of which is obsidian, pitchstone, and phonolite. This phenomenon is so much the more remarkable, as in Bohemia, and other parts of Europe, the *porphyrschiefer* with base of phonolite \* covers also the convex summits of the basaltic mountains.

as the *domites* of the Great-Sarcuy, of Puy-de-Dome, of the Little-Cleirsou, and of one part of the Puy Chopine in Auvergne.

\* *Klingstein*. Werner.

We have already observed, that from the level of the sea to Portillo, and as far as the entrance on the elevated plain of the Retama, that is two thirds of the total height of the volcano, the ground is so covered with plants, that it is difficult to make geological observations. The currents of lava, which we discover on the slope of Monte Verde, between the beautiful spring of Dornajito and Caravela, are black masses, altered by decomposition, sometimes porous, and with very oblong pores. The basis of these lower lavas is rather wacke than basalt; when it is spongy, it resembles the amygdaloids\* of Frankfort on the Main. It's fracture is generally irregular; wherever it is conchoidal, we may presume, that the cooling was more rapid, and the mass was exposed to a less powerful pressure. These currents of lava are not divided into regular prisms, but into very thin layers, not very regular in their inclination; they contain much olivine, small grains of magnetic iron, and augits, the color of which often varies from a deep leek green to an olive green, and which might be mistaken for crystallized olivine, though no transition from one to the other of these substances exists †. Hornblende,

\* *Wakkenartiger mandelstein* of Steinkaute.

† *Steffens, Handbuch der Oryktognosie*, T. i, s. 364. The crystals which Mr. Friesleben and myself have made known under the denomination of foliated olivine (*blättriger olivin*)

or amphibole, is in general very rare at Teneriffe, not only in the modern lithoid lavas, but also in the ancient basalts, as has been observed by Mr. Cordier, who resided longer at the Canaries than any other mineralogist. Nepheline, leucite, idocrase, and mejonite have not yet been seen at the Peak of Teneriffe; for a reddish gray lava, which we found on the slope of Monte Verde, and which contains small microscopic crystals, appears to me to be an intimate mixture of basalt and analcime \*. In the same manner the lava of la Scala, with which the city of Naples is paved, offers an intimate mixture of basalt, nepheline, and leucite. With respect to this last substance, which has hitherto been observed only at Vesuvius, and in the environs of Rome, it exists perhaps at the Peak of Teneriffe, in the old currents of lava that are covered by more recent ejections. Vesuvius during a long series of years † has also thrown out lavas without leucites: and if it be true, as Mr. Von Buch has

belong, according to Mr. Karsten, to the pyroxene, augit. *Journal des Mines de Freiberg*, 1791, p. 215.

\* This substance, which Mr. Dolomieu discovered in the amygdaloids of Catania in Sicily, and which accompanies the stilbites of Fassa in Tyrol, forms, with the chabasie of Haüy, the genus cubicit of Werner. Mr. Cordier found at Teneriffe zeolite in an amygdaloid which covers the basalts of La Punta di Naga.

† For instance in 1760, 1794, and 1805.

rendered very probable \*, that these crystals are formed only in the currents which flow either from the crater itself, or very near it's brink, we must not be surprised, if we do not find them in the lavas of the Peak, which are almost all owing to lateral eruptions, and which consequently have been exposed to an enormous pressure in the interior of the volcano.

In the plain of Retama, the basaltic lavas disappear under heaps of ashes, and pumice stone reduced to powder. Thence to the summit, from 1500 to 1900 toises in height, the volcano exhibits only vitreous lava with basis of pitchstone † and obsidian. These lavas, destitute of hornblende and mica, are of a blackish brown, often varying to the deepest olive green. They contain large crystals of feldspar, which are not fissured, and seldom vitreous. The analogy of those decidedly volcanic masses with the resinit porphyries ‡ of the valley of Tribisch in Saxony is very remarkable; but the latter, which belong to a very extended and metalliferous formation of porphyry §, often contain quartz,

\* *Leopold Von Buch, Geognostische Beob. t. 2, s. 221. Gilbert's Ann. t. 6, s. 53.* The existence of leucites (amphigènes) at Arendahl in Norway, in Scotland, in the Pyrenees, in Transylvania, in Mexico, does not rest on very accurate observations.

† *Petrosilex résinite.* Hatry.

‡ *Pechstein-porphyr.* Werner.

§ We can now distinguish four formations (*hauptnieder-*



which is wanting in the modern lavas. When the basis of the lavas of the Malpays changes

*lagen*) of porphyry. The *first* is primitive, and found in subordinate strata in the gneiss, and the mica-slate (Isaac at Freyberg). The *second* alternates with syenit: it is older than grauwakke, and belongs most probably already to the transition mountains (*uebergangs gebirge*). It contains beds of pitchstone and obsidian, and even granular limestone, of which we see instances near Meissen in Saxony: it is extremely rich in metals, and is found in Mexico at (Guanaxuato, Regla, &c.), in Norway, in Sweden, and at Schemnitz in Hungary. The porphyry of Norway covers, near Skeen, grauwakke and mandelstein; it encloses crystals of quartz. Near Holmestrandt, a bed of basalt, which abounds in augit, is interposed among the transition porphyry. The rock of Schemnitz (the *saxum metalliferum* of Ferber and Born), which lies on the thonschiefer, is destitute of quartz, and contains hornblende and common feldspar. It is this second formation of porphyry which appears to have been the centre of the oldest volcanic revolutions. The *third* formation belongs to the ancient sandstone (*todtesliegende*), which seems as a basis to the alpine limestone (alpen-kalkstein or zechstein): it contains mandelstein (amygdaloides) mixed with agate (at Oberstein, in the Palatinate), and sometimes covers (in Thuringia) strata of coal. The *fourth* formation of porphyries is trappean, destitute of quartz, and, especially in America, often mixed with olivin and augit; it accompanies basalts, greenstone, and phonolites (Chimborazo, the province de los Pastos, Drachenfels near Bonn, Puy-de-Dôme). The classification of the porphyries is accompanied with great difficulties. Granite, gneiss, mica slate or micaceous schist, thonschiefer, and chloritschiefer, forms a series, in which each rock is connected with that which precedes it. The porphyries, on the contrary, are found, as it were, isolated in the geognostical system; they offer transitions into each other, but not



from pitchstone to obsidian, the color is paler, and mixed with gray; in this case, the feldspar passes by imperceptible gradations from the common to the vitreous. Sometimes both varieties meet in the same fragment, as we observed also in the trappean porphyries of the valley of Mexico. The feldsparry lavas of the Peak, of a much less black color than those of Arso, in the isle of Ischia, whiten at the edge of the crater from the effect of the acid vapors; but their inside is no way deprived of color like that of the feldsparry lavas of the solfatara at Naples, which perfectly resemble the trappean

into the substances on which they repose. (*Buch, Geognost. Beob. t. i, s. 56.*) As in the course of this work volcanic and nonvolcanic porphyries may often occur, it appears to me indispensable, to exhibit the general table of the formation traced by the illustrious chief of the Freyberg school, from his own observation, those of Von Buch, Esmark, and Friesleben, and mine. The great divisions, which are susceptible of much improvement, are independent of any hypothesis on the origin of porphyries, as they relate only to position, superposition, and relative age. The four formations just described, may be distinguished by the names of primitive porphyries (*urporphyre*), of transition porphyries (*uebergangs-porphyre*), secondary porphyries (*flæzporphyre*), and trappean porphyries (*trapporphyre*). If we confound the second and fourth of these formations under the common name of porphyry-lavas, we throw geognosy back into the obscurity from which it is scarce freed: we might as well class gneiss, mica-slate, and thonschiefer, under the general name of laminar and schistose rocks.

porphyries at the foot of Chimborazo. In the middle of the Malpays, at the height of the cavern of ice, we found among the vitreous lavas with the pitchstone and obsidian basis, blocks of real greenish-gray, or mountain green phonolite, with a smooth fracture, and divided into thin laminae, sonorous and keen edged. These masses were the same as the porphyrschiefer of the mountain of Bilin in Bohemia; we recognized in them small long crystals of vitreous feldspar.

This regular disposition of lithoid basaltic lava and feldsparry vitreous lava is analogous to the phenomena of all trappean mountains; it reminds us of those phonolites lying in very ancient basalts, those intimate mixtures of augit and feldspar which cover the hills of wakke or porous amygdaloids: but why are the porphyritic or feldsparry lavas of the Peak found only on the summit of the mountain? Should we conclude from this position, that they are of a more recent formation than the lithoid basaltic lava, which contains olivine and augit? I cannot admit this last hypothesis; for lateral eruptions may have covered the feldsparry nucleus, at a period when the crater had ceased its activity. At Vesuvius also, we perceive small crystals of vitreous feldspar only in the very ancient lavas of the Somma. These lavas, setting aside the leucite, very nearly resemble the phonolitic productions of the Peak of Teneriffe. In

general the farther we go back from the period of modern eruptions, the more appearance the currents, increasing both in size and extent, acquire of real rocks, in the regularity of their position, in their division into parallel strata, or in their independence of the present form of the ground.

The Peak of Teneriffe is, next to Lipari, the volcano that has produced most obsidian. This abundance is so much the more striking, as in other regions of the Earth, in Iceland, in Hungary, in Mexico, and in the kingdom of Quito, we meet with obsidian only at great distances from burning volcanoes. Sometimes they are scattered over the fields in angular pieces, for instance, near Popayan, in South America; at other times they form isolated rocks, as at Quinche, near Quito; in other places, and this position is very remarkable, they are disseminated in perlstein, as at Cinapecuaro, in the province of Mechoacan\*, and at Cabo de Gates, in Spain. At the Peak of Teneriffe, the obsidian is not found toward the basis of the volcano, which is covered with modern lava: it is frequent only toward the summit, especially from the plain of Retama, where very fine specimens may be collected. This peculiar position, and the circumstance that the obsidian of the Peak has been ejected by a crater, which for ages

\* To the west of the city of Mexico.

past has thrown out no flames, are favourable to the opinion, that volcanic vitrifications, wherever they are found, are to be considered as of very ancient formation.

Obsidian, jade, and touchstone \*, are three minerals, which nations ignorant of the use of brass or iron, in all ages, employed to make keen-edged weapons. In the most distant parts of the Globe, necessity fixed their choice on the same substance. We see wandering hordes have dragged with them, in their distant excursions, stones, the natural position of which the mineralogist has not yet been able to discover. Hatchets of jade, covered with Azteck hieroglyphics, which I brought from Mexico, resemble both in their form and nature those made use of by the Gauls, and those we find among the islanders of the Pacific Ocean. The Mexicans dug obsidian in mines, which took up a vast extent of ground; and of it made knives, sword-blades, and razors. In like manner the Guanches, who called obsidian by the name of *tabona*, fixed splinters of this mineral to the ends of their lances. They carried on a considerable trade in it with the neighbouring islands; and from the consumption thus occasioned, and the quantity of obsidian which must have been broken in the fabrication, we may presume, that this mineral is become scarce from the lapse of ages.

\* Lydischerstein.



We are surprised to see an Atlantic nation substituting, like the Americans, vitrified lava for iron. In both countries, this variety of lava was employed as an object of ornament: the inhabitants of Quito made beautiful looking glasses with an obsidian divided into parallel laminæ.

There are three varieties of obsidian at the Peak. Some form enormous blocks, several toises long, and often of a spheroidal figure. We might suppose, that they had been thrown out in a softened state, and had undergone a rotary motion. They contain a quantity of vitreous feldspar, of a snow white color, and the most brilliant pearly lustre. These obsidians are nevertheless but little transparent on the edges, almost opaque, of a brownish black, and of an imperfect conchoidal fracture. They pass into pitchstone; and we may consider them as porphyries with a basis of obsidian. The second variety is found in fragments much less considerable. It is in general of a greenish black, sometimes of murky gray, very seldom of a perfect black, like the obsidian of Hecla and Mexico. Its fracture is perfectly conchoidal, and it is extremely transparent on the edges. I have found in it neither hornblende nor pyroxene, but some small white points, which seem to be feldspar. All the obsidians of the Peak are free from those gray masses of pearl or lavender blue, striped, and in separate pieces of the form of wedges,



contained in the obsidian of Quito, Mexico, and Lipari, and which resemble the fibrous plates of the *crystallites* of our glass houses, on which Sir James Hall, Dr. Thomson, and Mr. Fleuriau de Bellevue, have published some very curious observations \*.

The third variety of obsidian of the Peak is the most remarkable of the whole, from its connection with pumice stones. It is, like the former, of a greenish black, sometimes of a murky gray, but its very thin plates alternate with layers of pumice stone. Dr. Thomson's fine collection at Naples contained similar examples of lithoid lava of Vesuvius, divided into very distinct plates, only a line thick. The fibres of the pumice stone of the Peak are very seldom parallel to each other, and perpendicular to the strata of obsidian; they are most commonly irregular, asbestoidal, like fibrous glass-gall; and instead of being disseminated in the obsidian, like crystallites, they are found simply adhering to one of the external surfaces of this substance. During my stay at Madrid, Mr. Hergen showed me se-

\* *Bibl. Britann.* t. xv, p. 340; t. xxvii, p. 147. *Edin. Trans.*, vol. v, Pl. 1, No. 3. *Journ. de Phys.* an 12, floréal, et an 13, prairial. The name of crystallites has been given to the crystallized thin plates included in glass cooling slowly. Dr. Thomson and others indicate by the word *verre glasténisé*, glass which by slow cooling is wholly *unvitrified*, and has assumed the appearance of a fossile substance, or real *glass stone*.

veral specimens in the mineralogical collection of Don Jose Clavijo ; and for a long time the Spanish mineralogists considered them as undoubted proofs, that pumice stone owes it's origin to obsidian, in some degree deprived of color, and swelled by volcanic fire. I was formerly of this opinion, which must be confined to one variety only of pumice. I even thought, with many other geologists, that obsidian, so far from being vitrified lava, belonged to rocks that were not volcanic ; and that the fire, forcing it's way through the basalts, the green stone rocks, the phonolites, and the porphyries with basis of pitchstone and obsidian, the lavas and pumice stone were no other than these same rocks altered by the action of the volcanoes. The deprivation of color and extraordinary swelling, which the greater part of the obsidians undergo in a forge fire, their transition into pechstein, and their position in regions very distant from burning volcanoes, appear \* to be phenomena very difficult to reconcile, when we consider the obsidians as volcanic glass. A more profound study of nature, new journeys, and observations made on the productions of burning volcanoes, have led me to renounce those ideas.

It appears to me at present extremely probable, that obsidians, and porphyries with basis of obsidian, are vitrified masses, the cooling of

\* Ann. du Mus. d'Hist. nat. t. iii, p. 398.

which has been too rapid to change them into lithoid lava. I consider even the perlstein of Mr. Esmarck as an unvittrified obsidian: for among the minerals in the king's cabinet at Berlin there are volcanic glasses from Lipari, in which we see striated crystallites, of a pearl gray color, and of an earthy appearance, form gradual approaches to a granular lithoid lava, like the perlstein of Cinapecuaro, in Mexico. The oblong bubbles observed in the obsidians of each of the continents are incontestible proofs of their ancient state of igneous fluidity; and Dr. Thomson possesses specimens from Lipari, which are very instructive in this point of view, because fragments of red porphyry, or porphyry lavas, which do not entirely fill up the cavities of the obsidian, are found enveloped in them. We might say, that these fragments had not time to enter into complete solution in the liquified mass; they contain vitreous feldspar, and augit, and are the same as the celebrated columnar porphyries of the island of Panaria which, without having made part of a current of lavas, seem raised up in the form of hillocks, like so many porphyries in Auvergne, in the Euganean mountains, and in the Cordilleras of the Andes.

The objections against the volcanic origin of obsidians, drawn from their speedy loss of color, and their swelling by a slow fire, are deprived of their force by the ingenious experiments of Sir

James Hall. These experiments prove, that a stone, which is fusible only at thirty-eight degrees of Wedgwood's pyrometer, yields a glass, that softens at fourteen degrees; and that this glass, melted again and unvitriified (*glasténisé*), is fusible again only at thirty-five degrees of the same pyrometer. I applied the blowpipe to some black pumice stones from the volcano of the Isle of Bourbon, which, on the slightest contact of the flame, whitened and melted into an enamel.

But whether obsidians be primitive rocks, which have undergone the action of volcanic fire, or lavas repeatedly melted within the crater, the origin of the pumice stones which they envelope at the Peak of Teneriffe is not less problematic. This subject is the more worthy of being investigated, since it is generally interesting to the geology of volcanoes; and since an excellent mineralogist \*, after having visited Italy and the adjacent islands with great attention, affirms, that it is highly improbable, that pumice stone owes it's origin to the swelling of obsidian.

On recurring to the observations, which I have had the means of making in Europe, in the Canary islands, and in America, I conclude, that the term *pumice stone* does not denote a simple fossil, like the word calcedony, opal, or pyroxene,

\* M. Fleuriau de Bellevue, Journ. de Phys. t. lx, p. 451 et 461.



but that it indicates only a certain state, a capillary or fibrous form, under which several substances thrown out by volcanoes are seen. The nature of these substances is as different as the thickness, the tenacity, the flexibility, the parallelism, or the direction of their fibres. We may consequently doubt, whether pumice ought to hold any place in a system of oryctognosy; or whether, like compound rocks, they do not rather belong to the domain of geognosy. I have seen black pumice stones, in which augit and hornblende are easily recognised; they are less light, of a spongy texture, and rather cellular than fibrous. We might be tempted to think, that these substances owe their origin to basaltic lavas. I have observed them in the volcano of Pichincha, as well as in the tufa of Pausilippo, near Naples. Other pumice stones, and these the most common, are of a grayish white, or of a blueish gray, with numerous parallel fibres, and containing vitreous feldspar and mica. The greater part of the pumice stones of the Æolian islands, and those I collected at the foot of the volcano of Sotara, near Popayan, belong to this class. They seem to have been originally granitic rocks, as Dolomieu first recognised in his voyage to the islands of Lipari \*. Assembled in enormous blocks, they sometimes form whole

\* Dolomieu, *Voy. aux Iles de Lipari*, p. 67, *Id. Mém. sur les Iles Ponces*, p. 89.



mountains far from any active volcano. It is thus that we find obsidians between Llactacunga and Hambato, in the kingdom of Quito, covering the space of a league square ; and in Hungary, where they were accurately examined by Mr. Esmarck. This singular position made the Danish mineralogist think, that they belonged to the secondary or floetz formation ; and that the volcanic fire had traversed the strata of pumice, as well as the obsidians and the basalts, which he equally considers as not of volcanic origin. A third variety of pumice is that with fragile fibres, somewhat thick, transparent on the edges, and of an almost vitreous lustre, which exhibits the transition from the granitic pumice stone to the capillary glass. This variety, which is adherent to the green and grayish obsidian of the Peak of Teneriffe, seems to have been produced by the action of the fire on matters already vitrified.

From the whole of these considerations it results, that it is as erroneous to consider the whole of the pumice stones as tumefied obsidians, as to look for their origin exclusively in granites rendered fusile and fibrous by the action of fire, or of acid vapors. It is possible, that the obsidians themselves were only liquified granites \*;

\* We meet sometimes, though very rarely, with mica in the obsidians : and Dolomieu thinks he has found not only feldspar and mica, but also quartz, in the granitic pumice.

but we must distinguish, with Spallanzani, between the pumices which draw their origin directly from primitive rocks, and those which, being only altered volcanic productions, vary like them in their composition \*. A certain state, into which several heterogeneous substances pass, or the result of a particular mode of action, are insufficient to establish a *species* in the classification of simple minerals.

The experiments of Mr. Da Camara, and those I made in 1802, come in support of the opinion, that the pumice stones adherent to the obsidians of the Peak of Teneriffe do not unite to them accidentally, but are produced by the expansion of an elastic fluid, which is disengaged from the compact vitreous matter. This idea had for a long time occupied the mind of a person highly distinguished for his talents and reputation at Quito, who, unacquainted with the labors of the mineralogists of Europe, had devoted himself to researches on the volcanoes of his country. Don Juan de Larea, one of those lately sacrificed to the fury of faction, had been struck with the

Voy. aux Iles Ponces, p. 122; Voy. aux Iles de Lipari, p. 83.

\* The word *lava* is still more vague than that of pumice stone. "It is as little philosophical to require an exterior description of lava, as a mineral species, as it is to ask the general characters of the mass, that fills the veins of ore." Leop. Von Buch, *Geognost. Beob.* vol. ii, p. 173.

phenomena exhibited by obsidians exposed to a white heat. He had thought, that, wherever volcanoes act in the centre of a country covered with porphyry with base of obsidian, the elastic fluids must cause a swelling of the liquified mass, and act an important part in the earthquakes preceding eruptions. Without adopting an opinion, which seems somewhat bold, I made, in concert with Mr. Larea, a series of experiments on the tumefaction of the volcanic vitreous substances at Teneriffe, and on those which are found at Quinché, in the kingdom of Quito. To judge of the augmentation of their bulk, we measured pieces exposed to a forge fire of moderate heat by the water they displaced from a cylindric glass, enveloping the spongy mass with a thin coating of wax. According to our experiments, the obsidians swelled very unequally: those of the Peak and the black varieties of Cotopaxi and of Quinché increased near five times their bulk. The swelling on the contrary was very little perceptible in the obsidians of the Andes, the color of which is a brown approaching to red. When the reddish variety is mingled, in thin plates, with the black and blackish gray obsidians, the striated mass resembles porcelain jasper\*; and the opake parts resist the action of the fire for a length of time, while those which

\* Porzellan-jaspis of Werner; thermantide porcellanite of Haiiy.

are less rich in oxid of iron, lose their color and tumefy. What is this substance, the disengaging of which reduces the obsidian to the state of white pumice, sometimes fibrous, and at other times spongy, with oblong cells? It is easy to perceive, that it easily loses a coloring principle; and that the deprivation of color is not merely apparent, that is to say, it is not owing to the extreme tenuity to which the laminæ and fibres of the volcanic glass are reduced. Can we admit, that this coloring principle \* is a hydruret of carbon, analogous to that which perhaps exists in the flint so easy to whiten by fire? Some experiments, which I made at Berlin in 1806 jointly with Messrs. Rose and Karsten, on the obsidians of Teneriffe, Quito, Mexico, and Hungary, in porcelain *retorts*, did not yield any results that were satisfactory.

Nature probably employs very different means to produce the spongy and vitreous pumices of Teneriffe, the pumices with parallel fibres of the Æolian islands and of Llactacunga †, and the capillary vitrifications of the Isles of Bourbon,

\* It is remarkable, that this principle is not always equally volatile. Mr. Gay-Lussac saw lately obsidians of Faroë not whiten at a degree of heat, which totally deprived of color obsidians of Mexico, though from exterior appearance it would have been difficult to distinguish these substances from one another.

† Between Quito and Riobamba.



which sometimes resemble a spider's web\*. We may admit, that these differences consist principally in the degree of heat of the volcanic fire, in the pressure under which this fire acts, and in the nature of the rocks altered by it. Above all, the pressure, which the obsidians undergo in their fusion, explains why these substances, except some varieties which I collected near Popayan, are never found whitened. Those of the pumice stones that have the appearance of being formed at great depths, are fibrous, of silky lustre, which abound more in mica than in feldspar, and in which, on the Andes, blocks of eight or ten toises in length have the fibres exactly parallel with each other, and perpendicular to the direction of the strata. Several volcanoes too do not throw out any pumice stone; and those that do, eject them only by their crater, after the flowing of the lavas. Several mineralogists think, that primitive granular rocks may be changed progressively, and in their place, either by the fire, or by a penetration of hot and acid vapors, into porphyroidal masses, of a foliate or fibrous texture. This opinion seems supported by the existence of the fissured and fibrous feldspars, which we found in the trap-pean porphyries of Quito. These crystals re-

\* Bory de St. Vincent, *Voy. aux Iles d'Afrique*, t. iii, p. 50.



semble rhomboidal fragments of pumice stone, disseminated in a *domite* deprived of color.

The color of the pumice stones of the Peak leads to another important observation. The sea of white ashes, which encircles the Piton, and covers the vast plain of Retama, is a certain proof of the ancient activity of the crater: for in all volcanoes, even when there are lateral eruptions, the ashes and the *rapilli* issue jointly with the vapours only from the opening at the summit of the mountain. Now, at Teneriffe, the black *rapilli* extend from the foot of the Peak to the sea-shore; while the white ashes, which are only pumice ground to powder, and among which I have discovered, with a lens, fragments of vitreous feldspar and pyroxene, exclusively occupy the region next to the Peak. This particular distribution seems to confirm the observations made a long time ago at Vesuvius, that the white ashes are thrown out the last, and indicate the end of the eruption. In proportion as the elasticity of the vapors diminishes, the matter is thrown to a less distance; and the black *rapilli*, which issue the first, when the lava has ceased running, must necessarily reach farther than the white *rapilli*. The last appear to have undergone the action of a more intense fire.]

I have now examined the exterior structure of the Peak, and the composition of its volcanic productions, from the region of the coast to the

top of the Piton. I have endeavoured to render these researches interesting, by comparing the phenomena of the volcano of Teneriffe with those that are observed in other regions, the soil of which is equally undermined by subterranean fires. This mode of viewing Nature in the universality of her relations is no doubt prejudicial to the rapidity suitable to an itinerary; but I thought, that, in a narrative, the principal end of which is the progress of physical knowledge, every other consideration ought to be subservient to those of instruction and utility. It is by isolating facts, that travellers on every other account respectable, have given birth to so many false ideas of the pretended contrasts, which Nature offers in Africa, in New Holland, and on the ridge of the Cordilleras. The great geological phenomena are subject to the same laws, as well as the forms of plants and animals. The ties which unite these phenomena, the relations which exist between such varied forms of organized beings, are discovered only when we have acquired the habit of viewing the Globe as a great whole; and when we consider in the same point of view the composition of rocks, the forces which alter them, and the productions of the soil, in the most distant regions.

After having treated of the volcanic substances of the isle of Teneriffe, we have to solve a question intimately connected with the preceding in-

vestigation, which in these latter times has much engaged the attention of mineralogists. Does the Archipelago of the Canary islands contain any rocks of primitive or secondary formation ; or is there any production observed, that has not been modified by fire ? This interesting problem has been examined by the naturalists with Lord Macartney, and by those who accompanied Captain Baudin in his voyage to the Austral lands. The opinions of these distinguished scientific men are in direct opposition to each other ; and a contradiction of this nature is so much the more striking, as there is no question here of one of those geological reveries, which we are accustomed to call systems, but of a positive fact, easy to verify.

Doctor Gillan, according to the narrative of Sir George Staunton \*, imagined, that he observed, between Laguna and the port of Orotava, in very deep ravines, beds of primitive rocks. This assertion, though repeated by a number of travellers, who copy each other, is not the less inaccurate. What Dr. Gillan calls somewhat vaguely, *mountains of hard ferruginous clay*, are nothing but an alluvion, which we find at the foot of every volcano. Strata of clay accompany basalts, as tufas the modern lavas. Neither Mr. Cordier nor myself observed in any part of Teneriffe a primitive rock, either in it's natural place,

\* Voy. de Lord Macartney, t. i. p. 15.

or thrown out by the mouth of the Peak ; and the absence of these rocks characterizes almost every island of small extent, that has an unextinguished volcano. We know nothing positive of the mountains of the Azores ; but it is certain, that the island of Reunion \*, as well as that of Teneriffe, exhibits only a heap of lavas and basalts. No volcanic rock rears it's head, either on the Gros Morne †, or on the volcano of Bourbon, or on the colossal pyramid of Cimañef, which is perhaps more elevated than the Peak of the Canary islands.

It is nevertheless asserted ‡, that lavas including fragments of granite have been found on the elevated plain of Retama. Mr. Broussonet informed me, a short time before his death, that, on a hill above Guimar, fragments of mica-slate, containing beautiful plates of specular iron, had been found. I can affirm nothing respecting the accuracy of this observation, which it would be so much the more important to verify, as Mr.

\* The Isle of Bourbon.

† Blocks of granite, thrown out probably by the ancient volcano of the Gros Morne, are found near the source of Trois-Rivières ; and this fact is so much the more worthy attention, as the neighbouring islands, known under the name of Sechelles, are formed of granitic rocks.—*Bory de St. Vincent, Voy. aux Iles d'Afrique*, t. i, p. 338 ; t. ii, p. 35 ; t. iii, p. 145 et 246.

‡ Bory de St. Vincent, *Essai sur les Iles Fortunées*, p. 278.



Poli, of Naples, is in possession of a fragment of rock thrown out by Vesuvius \*, which I found to be a real mica-slate. Every thing that tends to enlighten us with respect to the site of the volcanic fire, and the position of rocks subject to it's action, is highly interesting to geology.

It is possible, that, at the Peak of Teneriffe, the fragments of primitive rocks thrown out by the mouth of the volcano were less rare than they appear to be, and are heaped together in some ravine, which may not yet have been visited by travellers. In fact, at Vesuvius, these same fragments are met with only in one single place, at the *Fossa-Grande*, where they are hidden under a thick layer of ashes. If this ravine had not long ago caught the attention of naturalists, when masses of granular limestone, and

\* In the valuable collection of Dr. Thomson, who resided at Naples till 1805, is a fragment of lava enclosing a real granite, which is composed of reddish feldspar with a pearly lustre like adularia, quartz, mica, hornblende, and, what is very remarkable, lazulite. But in general the masses of known primitive rocks, I mean those which perfectly resemble our granites, our gneiss, and our mica-slates, are very rare in lavas ; the substances we commonly denote by the name of granite thrown out by Vesuvius are mixtures of nepheline, mica, and pyroxene. We are ignorant whether these mixtures constitute rocks *sui generis* placed under granite, and consequently of more ancient date ; or simply form either intermediate strata or veins, in the interior of the primitive mountains, the tops of which appear at the surface of the Globe.



other primitive rocks, were laid bare by the rains, we might have thought them as rare at Vesuvius, as they are, at least in appearance, at the Peak of Teneriffe.

With respect to the fragments of granite, gneiss, and mica-slate, which we find on the shores of Santa Cruz and Orotava, they do not come from the opposite coasts of Africa, which are calcareous, but were probably brought in ships as ballast. They no more belong to the soil where they lie, than the feldsparry lavas of Etna, which we observe in the pavements of Hamburgh and other towns of the north. The naturalist is exposed to a thousand errors, if he loses sight of the changes, which the intercourse between nations produces on the surface of the Globe. We might be led to say, that man, expatriating himself, is desirous that every thing should change country with him. Not only plants, insects, and different species of small quadrupeds, follow him across the ocean; his active industry covers the shores with rocks, that he has torn from the soil in distant climes.

If it be certain, that no enlightened observer has hitherto found at Teneriffe primitive strata, or even those trappean and ambiguous porphyries, which constitute the basis of Etna \*, and of

\* The Chevalier Gioeni, who, like several mineralogists of Germany and France, distinguishes the basalts from the modern lavas, considers Etna as a mountain of porphyry, sur-

several volcanoes of the Andes, we must not conclude from this isolated fact, that the whole of the Archipelago of the Canaries is the production of submarine fires. The island of Gomera contains mountains of granite and mica-slate \*, and it is undoubtedly in these very ancient rocks, that we must here seek, as well as on all other parts of the Globe †, the centre of the volcanic action.

mounted by columnar basalts, which serve, in their turn, as a basis to the feldsparry lavas. The last alone appear to be owing to the present volcano. The basalts and the porphyries belong to a system of older mountains, which cover a great part of Sicily. The porphyries of Etna are volcanic without doubt; but every rock which owes it's composition and it's form to the action of fire and vapors, has not made part of a current of lavas. These observations appeared to me so much the more necessary, as some very distinguished mineralogists have recently affirmed, that the Peak of Teneriffe and Vesuvius are mountains of porphyry of Neptunian origin, and undermined by subterranean fires. The lava of *la Scala* has been described without hesitation as a particular rock, under the name of *graustein*, though it issued from the crater at a well known epocha, in 1631: some have even gone farther; they have supposed, that Somma exhibits the untouched nucleus of Vesuvius, though it's stratified mass, traversed by veins filled with more recent lava, is identical with the rock constituting the actual crater, which has evidently been in a state of fusion. Somma exhibits the same leucites as abound in the greater part of the lavas of Vesuvius, and their crystals are included in a phonolite resembling that of the top of the Peak of Teneriffe.

\* Note manuscrite de M. Broussonet.

† Dolomieu, in the Journ. de Phys. 1798, p. 414.

Hornblende, sometimes pure and forming intermediate strata, at other times mixed with granite, as in the *basanites* or basalt of the ancients, may, by itself, furnish all the iron contained in the black and stony lavas. This quantity amounts in the basalt of the modern mineralogists only to 0·20, while in hornblende it exceeds 0·30.

Were these granites and these mica-slates of Gomera anciently united to the chain of Atlas, as the primitive mountains of Corsica appear to be the central nucleus of Bochetta and the Apennines? This question can never be solved, till mineralogists shall have visited the islands that surround the Peak, and the mountains of Morocco covered with eternal snows. Whatever at some future day may be the result of these investigations, we could not admit with Mr. Peron \*, “ that in none of the Canary Islands do we meet with true granites; and that, the whole of the Archipelago being exclusively volcanic, the partisans of the Atlantis must suppose, what is equally destitute of probability, either a continent perfectly volcanic, or that only the volcanic parts of that continent were spared in the catastrophe, by which it was swallowed up.”

From the information of several well instructed persons, to whom I addressed myself, I found, that there are calcareous formations in

\* Voyage de Déconvertes aux Terres Australes, t. i, p. 24.

the Great Canary, Fortaventura, and Lanzerota \*. I was not able to determine the nature of this secondary rock; but it appears certain, that the island of Teneriffe is altogether destitute of it; and that among it's alluvial lands it exhibits only clayey calcareous tufa, but which alternates with volcanic breccias, and which, according to Mr. Vieyra †, contains near the village of La Rambla, at Calderas, and near Candelaria, plants, imprints of fishes, buccinites, and other fossil marine productions. Mr. Cordier has brought away some of this tufa, which resembles that in the environs of Naples and Rome, and contains fragments of reeds. At the Salvages, which La Pérouse took at a distance for a mass of scoriæ, even fibrous gypsum is found.

I had seen, while herbalizing between the port of Orotava and the garden of La Paz, heaps of grayish calcareous stones, of an imperfect conchoidal fracture, and analogous to that of Mount Jura and the Apennines. I was inform-

\* At Lanzerota calcareous stone is burned to lime with a fire made of the alhulaga, a new species of thorny and arborescent sonchus.

† Noticias historicas, t. i, p. 35. The Isle of France, which rises in the form of a pyramid, and in the disposition of it's volcanic hills has many points of resemblance with Teneriffe, has a Neptunian plain in the quartier des Pamplemousses. The calcareous stone there is filled with madrepores. *Bory de St. Vincent*, t. i, p. 207.



ed, that these stones were extracted from a quarry near Rambla ; and that there were similar quarries near Realejo, and the mountain of Roxas, above Adexa. This information, probably not very accurate, led me into an error. As the coasts of Portugal consist of basalts covering calcareous rocks containing shells, I thought, that a trappean formation, like that of the Vicentin in Lombardy, and of Harutsch in Africa, might have extended from the banks of the Tagus and Cape St. Vincent as far as the Canary Islands ; and that the basalts of the Peak might perhaps conceal a secondary calcareous stone. I mentioned these ideas in a letter, which was not intended to be made public ; and they have exposed me to the severe reprehension of a naturalist, according to whom every volcanic island is only an accumulation of lavas and scorïæ, and who admits no fact contrary to his own theory of volcanoes\*.

Though Teneriffe belongs to a group of islands

\* Examination of certain geological opinions of Mr. de Humboldt, by Mr. G. A. De Luc (*Journ. de Phys.* t. 50, P. 1, p. 114). This memoir, in which we recognise an excellent observer, is the continuation of another against Mr. Kirwan, who thinks, that the lavas of Vesuvius repose on the calcareous beds of the Apennines. *Ibid.* vol. xlix. p. 23. According to the *Theories of Volcanoes*, given by Mr. De Luc, it is impossible, that a real lava should contain fragments of vegetable substances. Our collections, however, contain pieces of trunks of palm-trees, enclosed and penetrated by the



of considerable extent, the Peak exhibits nevertheless all the characters of a mountain placed on a solitary islet. As at St. Helena, the lead finds no bottom \* at a little distance from the ports of Santa Cruz, Orotava, and Garachico. The ocean, as well as the continents, has it's mountains and it's plains; and, if we except the Andes, the volcanic cones are formed every where in the regions of the Globe.

As the Peak rises amid a system of basalts and old lava, and as the whole part which is visible above the surface of the waters exhibits burnt substances, it has been supposed, that this immense pyramid is the effect of a progressive accumulation of lavas; or that it contains in it's centre a nucleus of primitive rocks. Both of these suppositions appear to me improbable. I think that there as little existed mountains of granite, gneiss, or primitive calcareous stone, where we at present see the tops of the Peak, of Vesuvius, and of Etna, as in the plains where almost in our own time has been formed the volcano of Jorullo, which is more than a third of the height of Vesuvius. On examining the circumstances which accompanied the formation of the new island in the Archipelago of the

very liquid lava of the Isle of Bourbon. See the interesting memoir of Mr. de Fleuriau, *l. c.* vol. lx, p. 441.

\* *Voy. de l'Isis*, vol. i, p. 287; *Voy. de Marchand*, t. i, p. 542.

Azores\*; on carefully reading the minute and ingenuous narrative, which the Jesuit Bourguignon gave of the slow appearance of the islet of the little Kameni, near Santorino; we find, that these extraordinary eruptions are generally preceded by a swelling of the softened crust of the Globe. Rocks appear above the waters before the flames force their way, and lava can issue from the crater; we must distinguish between the nucleus raised up, and the mass of lavas and scorix, which successively increase it's dimensions.

It is true, in all the revolutions of this kind, which have taken place since the time that their history has been written, the perpendicular height of the stony nucleus appears never to

\* Sabrina island. See the letter of Captain Tillard to Sir Joseph Banks, *Philos. Trans. for 1812*, p. 152. At Sabrina island, near St. Michael's, the crater opened at the foot of a solid rock, of almost a cubical form. This rock, terminated by a small elevated plain perfectly even, is more than two hundred toises in breadth. It's formation was anterior to that of the crater, into which, a few days after it's opening, the sea made an irruption. At Kameni, the smoke was not even visible till twenty-six days after the appearance of the raised rocks. *Phil. Trans.* vol. xxvi, p. 69 and 200; vol. xxvii, p. 353. All these phenomena, on which Mr. Hawkins collected very valuable observations during his abode at Santorino, are unfavorable to the idea commonly entertained of the origin of volcanic mountains, which ascribes them to a progressive accumulation of liquified matter, and the diffusion of lavas issuing from a central mouth.

have exceeded one hundred and fifty or two hundred toises ; even taking into the account the depth of the sea, the bottom of which had been lifted up : but when we are considering the great effects of nature, and the intensity of it's forces, it is not the bulk of the masses, that ought to stop the geologist in his speculations. Every thing indicates, that the physical changes of which tradition has preserved the remembrance, exhibit but a feeble image of those gigantic catastrophes, which have given mountains their present form, changed the positions of the rocky strata, and buried seashells on the summit of the higher Alps. It was undoubtedly in those remote times, which preceded the existence of the human race, that the raised crust of the Globe produced those domes of trappean porphyry, those hills of isolated basalt on vast elevated plains, those solid nuclei which are clothed in the modern lavas of the Peak, of Etna, and of Cotapaxi. The volcanic revolutions have succeeded each other after long intervals, and at very different periods ; of this we see the vestiges in the transition mountains, in the secondary strata, and in those of alluvion. Volcanoes of earlier date than the sandstone and calcareous rocks have been for ages extinguished ; those which are yet in activity are in general surrounded only with breccias and modern tufas ; but nothing hinders us from admitting, that the

archipelago of the Canaries may exhibit some real rocks of secondary formation, if we recollect, that subterraneous fires have been there re-kindled, in the midst of a system of basalts and very ancient lavas.

I should wander too long from the principal object of my researches, were I to pursue a subject, in which mere conjecture supplies the place of geological fact. From those dark times, when the elements, subjected to the same laws, had not yet attained their present equilibrium, I come back to a period less tumultuous, nearer our own age, and on which tradition and history may throw some light. We seek in vain in the *Periplus* of Hanno or of Scylax the first notions written on the eruptions of the Peak of Teneriffe. Those navigators sailed timidly along the coast, anchoring every evening in some bay, and had no knowledge of a volcano distant fifty-six leagues from the coast of Africa. Hanno nevertheless relates, that he saw torrents of light, which seemed to fall on the sea; that every night the coast was covered with fires; and that the great mountain, called the *Cur of the Gods*, had appeared to throw up sheets of flame, which rose even to the clouds. But this mountain, placed to the north of the island of the Gorilli\*,

\* It was in this island that the Carthaginian admiral saw, for the first time, a large species of apes of human form, the Gorilli. He describes them like women, their body covered



formed the western extremity of the chain of Atlas ; and it is also very uncertain, whether the flames seen by Hanno were the effect of some volcanic eruption, or whether they should be attributed to the custom, common to so many nations, of setting fire to the forests and dry grass of the savannahs. In our own days similar doubts were entertained by the naturalists, who, in the voyage of d'Entrecasteaux, saw the island of Amsterdam covered with a thick smoke\*. On the coast of the Caraccas, trains of reddish fire, fed by the burning grass, exhibited to me, for several nights, the delusive aspect of a current of lava, descending from the mountains, and dividing itself into several branches.

Though the journals of Hanno and Scylax, in the state in which they have reached us, contain no passage, which we can reasonably apply to the Canary islands, it is however very probable, that the Carthaginians, and even the Phœni-

entirely with hair, and very mischievous, because they defended themselves with their teeth and nails. He boasts of having flayed three of them to preserve their skins. Mr. Gosselin places the isle of the Gorilli at the mouth of the river Nun ; but, according to this account, the lake, near which Hanno saw a multitude of elephants feeding, should be in the latitude of thirty-five and a half, almost at the northern extremity of Africa. *Recherches sur la Géographie des Anciens*, t. i, p. 74 et 98.

\* *Voy. de Labillardière*, t. 1, p. 112. *Voy. de d'Entrecasteaux*, t. i, p. 45.



cians, had some knowledge\* of the Peak of Teneriffe. In the time of Plato and Aristotle, vague notions of it had reached the Greeks, who considered the whole of the coast of Africa, beyond the Pillars of Hercules, as thrown into disorder by the fire of volcanoes†. The Place of the Blessed, which was sought first in the north, beyond the Riphean mountains, among the Hyperboreans‡, and then to the south of Cyrenaica, was situate in regions that were considered as toward the west, where the world

\* See a treatise by Mr. Ideler, inserted in my *Views of Nature*, t. i, p. 141; and Gosselin, *Recherches*, t. i, p. 135—159. One of the most distinguished writers of Germany, Mr. Heeren, thinks, that the Fortunate Islands of Diodorus Siculus were Madeira and Porto Santo. *Afrika*, t. i, p. 124. *Malte-Brun*, *Histoire de la Géographie*, p. 76, 90, et 194.

† *Arist. Mirab. Auscult.* (ed. Casaub.) p. 704. Solinus says of Atlas, *vertex semper nivalis lucet nocturnis ignibus*; but this Atlas, which, like the mountain Meru of the Hindoos, exhibits a mixture of true ideas and mythological fictions, was not situate in one of the islands of the Hesperides, as the Abbé Vieyra admits, and after him several travellers, who have described the Peak of Teneriffe (*Vieyra*, t. i, p. 225; *Dory de St. Vincent*, p. 395). The following passages leave no doubt on this head. *Herod.* iv, 184; *Strabo*, xvii (ed. Falconer, t. ii, p. 1167); *Mela*, iii, 10; *Pliny*, v. 1; *Solinus*, i, 24; and even *Diod. Sic.* iii. (ed. Wess. t. i, p. 221).

‡ *Mannert. Geogr. der Griechen*, t. iv, s. 57. The idea of the happiness, of the great civilization, and of the riches of the inhabitants of the north, was common to the Greeks, to the people of India, and to the Mexicans.

known to the ancients terminated. The name of Fortunate Islands had long been as vague a signification, as that of *Dorado* among the first conquerors of America. Happiness was thought to reside at the end of the Earth, as we seek for the most exquisite enjoyments of the mind in an ideal world beyond the limits of reality.

We must not be surprised, that, previous to the time of Aristotle, we find no accurate notion respecting the Canary islands, and the volcanoes they contain, among the Greek geographers. The only nation, whose navigations extended toward the west and the north, the Carthaginians, were interested in throwing a veil of mystery over those distant regions. While the senate of Carthage was averse to any partial emigration, it pointed out these islands as a place of refuge in times of trouble and public misfortune; they were to the Carthaginians, what the free soil of America is become to Europeans amidst their religious and civil dissensions.

The Canaries were not better known to the Romans till eighty-four years before the reign of Octavian. A private individual was desirous of executing the project, which wise foresight had dictated to the senate of Carthage. Sertorius, conquered by Sylla, wearied with the tumult of arms, looks out for a safe and peaceable retreat. He chooses the Fortunate Islands, of which a delightful picture had been drawn for

him on the coasts of Bætica. He carefully combines the notions he can acquire from travellers ; but in the little that has been transmitted to us of these notions, and in the more minute descriptions of Sebosus and Juba, there is no mention of volcanoes or volcanic eruptions. Scarcely can we recognise the isle of Teneriffe, and the snows with which the summit of the Peak is covered in winter, in the name of *Nivaria*, given to one of the *Fortunate Islands*. Hence we might conclude, that the volcano at that time threw out no flames ; if it were permitted to interpret the silence of a few authors, whom we know only by short fragments, or dry nomenclatures. The naturalist vainly seeks in history for documents of the first eruptions of the Peak, he no where finds any but in the language of the Guanches, in which the word *Echeyde*\* denotes at the same time Hell and the volcano of Teneriffe.

Of all the written testimonies, the oldest I have found of the activity of this volcano dates from the beginning of the sixteenth century. It

\* The same mountain bore the name of *Aya-dyrma*, in which Horn (*de Originib. Americ.* p. 155 and 185) imagines he finds the ancient denomination of Atlas ; which, according to Strabo, Pliny, and Solinus, was Dyris. This etymology is very doubtful ; but in not giving more importance to the vowels, than they have among the people of the East, we find Dyris almost complete in the word *Daran*, by which the Arabian geographers denote the eastern part of Mount Atlas.

is contained in the narrative of the voyage\* of Aloysio Cadamusto, who landed at the Canaries in 1505. This traveller was witness of no eruptions, but he positively affirms, that, like Etna, this mountain burns without interruption, and that the fire has been seen by Christians retained in slavery by the Guanches of Teneriffe. The Peak therefore was not at that time in the state of repose, in which we find it at present; for it is certain, that no navigator or inhabitant of Teneriffe, has seen issue from the mouth of the Peak, I will not say flames, but even any smoke that was visible at a distance. Perhaps it is to be wished, that the funnel of the Caldera may open anew; the lateral eruptions would thus be rendered less violent, and the whole group of islands would have less to fear from the effects of earthquakes †.

\* Nec silendum puto de insula Teneriffæ, quæ et eximie colitur, & inter orbis insulas est eminentior. Nam cælo sereno eminens conspicitur; adeo ut qui absunt ab ea ad leucas hispanas sexaginta vel septuaginta non difficulter eam intueantur. Quod cernatur a longe id efficit acuminatus lapis adamantinus, instar pyramidis, in medio. Qui metiti sunt lapidem aiunt altitudine lucarum quindecim mensuram excedere ab imo ad summum verticem. Is lapis jugiter flagrat, instar Ætnæ montis; id affirmant nostri Christiani, qui capti aliquando hæc animadvertère. *Aloysii Cadamusti Navigatio ad Terras Incognitas*, c. 8.

† At Teneriffe the shocks have hitherto been very considerable, and limited to a small extent of ground. The same thing has been observed at the Isle of Bourbon, and almost



I have heard the question discussed at Orontava, whether it can be admitted, that in the lapse of ages the Peak will begin again to act. In a matter so doubtful, analogy alone can serve as a guide. Now according to the report of Braccini, the interior of the crater of Vesuvius was covered with shrubs in 1611. Every thing then indicated the greatest tranquility; and nevertheless twenty years after, the same gulf, which seemed transformed into a shadowy vale, threw out sheets of fire, and an enormous quantity of ashes. Vesuvius resumed in 1631 the same activity it had in 1500. In the same manner it is possible, that the crater of the Peak may change it's appearance at some future period. It is a solfatara like the tranquil solfatara of Puzzuoli; but it is placed on the summit of a volcano yet in activity.

The eruptions of the Peak have been very rare for two centuries past, and these long intervals appear to characterize volcanoes highly elevated. The smallest of the whole, Stromboli, is almost always burning. At Vesuvius, the eruptions are already rarer, though still more frequent than those of Etna and the Peak of Teneriffe. The

every where at the foot of burning volcanoes. At Naples, earthquakes precede the eruptions of Vesuvius, they cease when the lava begins to flow, and are in general very feeble in comparison of those felt on the slope of the calcareous Apennines.



colossal summits of the Andes, Cotopaxi, and Tungurahua, scarcely have an eruption once in a century. We might say, that in active volcanoes the frequency of the eruptions is in the inverse ratio of the height and the mass. The Peak also had seemed extinguished during ninety-two years, when, in 1798, it made it's last eruption by a lateral opening formed in the mountain of Chahorra. In this interval Vesuvius had sixteen eruptions.

I have observed in another place\*, that the whole of the mountainous part of the kingdom of Quito may be considered as an immense volcano, occupying more than seven hundred square leagues of surface, and throwing out flames by different cones, known under the particular denominations of Cotopaxi, Tungurahua, and Pichincha. In like manner, the whole group of the Canary islands is placed, as it were, on the same submarine volcano. The fire makes it's way sometimes by one and sometimes by another of these islands. Teneriffe alone contains in it's centre an immense pyramid terminated by a crater, and throwing out from one century to another, lava by it's flanks. In the other islands, the different eruptions have taken place in various parts; and we no where find those isolated mountains, to which the volcanic effects are restrained. The basaltic crust, formed by ancient

\* Géograph. Végét. p. 130.

volcanoes, seems every where undermined ; and the currents of lava, seen at Lanzerota and Palma, remind us by every geological affinity of the eruption, which took place in 1301 at the isle of Ischia, amid the tufas of Epomeo.

The following is a statement of the volcanic phenomena, of which the historians of the Canary islands have preserved the remembrance since the middle of the sixteenth century.

#### Year 1558.

At the period when the island of Teneriffe was ravaged for the first time by the plague brought from the Levant, a volcano burst open, on the 15th of April, in the isle of Palma, near a spring in the Partido de los Llanos. A mountain rose from the earth ; and formed a crater at the top, which threw out a current of lava a hundred toises in breadth, and more than two thousand five hundred in length. The lava flowed into the sea, and raising the temperature of the water, destroyed the fish\* at great distances around.

#### Year 1646.

The 13th of November, a volcanic mouth

\* This same phenomenon took place in 1811, near the Azores, when the volcano of Sabrina opened at the bottom of the ocean. The calcined skeleton of a shark was found in the inundated and extinguished crater.

opened in the island of Palma, near Tegalate. Two others were formed on the seashore. The lavas which issued from these crevices dried up the celebrated spring of Furcaliente, or Fuente Santa; the mineral waters of which attracted the visits of the diseased, who flocked thither even from Europe. According to a popular tradition, the eruption ceased in a very extraordinary manner. The image of our Lady of the Snows of Santa Cruz, was carried to the mouth of the new volcano, and immediately there fell such an immense quantity of snow, that the fire was extinguished. In the Andes of Quito, the Indians think they have observed, that an abundance of snow water filtrating into volcanoes increases their activity.

#### Year 1677.

Third eruption in the isle of Palma. The mountain de Las Cabras threw out scorixæ and ashes through a multitude of small mouths, which were formed in succession.

#### Year 1704.

On the 31st of December, the Peak of Teneriffe formed a lateral eruption in the plain De los Infantes, above Icore, in the district of Guimar. Tremendous earthquakes preceded this eruption. On the 5th of January 1705, a second opening took place in the ravine of Almerchiga,

a league from Icore. The lavas were so abundant, that the whole valley of Fasnía, or Areza, was filled up. This second mouth ceased its eruption on the 13th of January. A third was formed the 2d of February, in the Canada de Arafo. The lavas divided into three currents, and threatened the village of Guimar; but they were stopped in the valley of Melosar by a chain of rocks, which formed an insuperable obstacle to their passage. During these eruptions, the town of Orotava, separated from the new mouths by a very narrow dyke, felt strong shocks.

#### Year 1706.

On the fifth of May another lateral eruption of the Peak of Teneriffe took place. The mouth opened on the south of the port of Garachico, which was then the finest and most frequented harbour in the island. This opulent and populous city was built on the edge of a forest of laurels, in a very picturesque situation. Two currents of lava destroyed it in a few hours, not a single edifice being left standing. The port, which had already suffered in 1645 by the accumulation of sand and mud caused by a great inundation, was so filled up, that the lavas formed a promontory in the midst of it. In the environs of Garachico, the surface of the ground changed its appearance. Hills arose in the plain; the springs became dry; and the rocks,



shaken by frequent earthquakes, remained naked, without vegetation, and without mould. The fishermen only retained their affection for their native spot. Intrepid, like the inhabitants of the Torre del Greco, they rebuilt a small village on the masses of scoriæ, and on the vitrified rock.

#### Year 1730.

On the 1st of September a dreadful revolution broke up the ascent of the Isle of Lanzerota. A new volcano opened at Temanfaya. The lavas which flowed, and the earthquakes which accompanied the eruption, destroyed a considerable number of villages; among which were the three old Guanche townships of Tingafa, Macintafe, and Guatisca. The shocks lasted till 1736; and the greater part of the inhabitants of Lanzerota fled to the island of Fortaventura. During this eruption, which has been noticed in the preceding chapter, a column of thick smoke was seen to issue from the sea. Pyramidal rocks rose above the surface of the waters; and these new rocks gradually extending, became a part of the island itself.

#### Year 1798.

On the 9th of June, there was a lateral eruption of the Peak of Teneriffe, by the flanks of the mountain of Chahorra, or Venge \*, in a place

\* The slope of the mountain of Venge, on which the erup-



entirely uncultivated, to the south of Icod, near the village of Guia, the ancient Isora. This mountain, backed by the Peak, was at all times considered as an extinguished volcano. Though formed of solid matter, it is with respect to the Peak, what Monte Rosso, which appeared in 1661, and the Boche nuove of 1794, are to Vesuvius and Etna. The eruption of Chahorra lasted three months and six days. The lavas and scoriæ were thrown out by four mouths, placed in the same line. When the lava had gained three or four toises in height, it advanced three feet every hour. This eruption took place but a year before my arrival at Teneriffe, and had left a durable impression among the inhabitants. I saw at the house of Mr. Legros, at Durasno, a drawing of the mouths of the Chahorra, which he had taken on the spot. Don Bernardo Cologan had visited these mouths eight days after they were opened, and he had described the principal phenomena of this eruption in a memoir, of which he gave me a copy to insert in the narrative of my travels. Thirteen years having elapsed since that period, and Mr. Bory de St. Vincent having preceded me in the publication of this memoir, I refer the reader for it to his interesting *Essay on the Fortunate*

tion took place, is called Chazajanne. See Nicolas de Segundo de Franqui, in Cavanilles y Hergén, *Annales de Historia natural*, t. i, p. 298.

*Islands* \*. I shall only mention some circumstances respecting the height, to which very considerable fragments of rocks were projected by the mouths of the Chahorra. Mr. Cologan † reckoned from twelve to fifteen seconds during the fall of these stones, that is to say, beginning to count from the moment they had reached the maximum of their height. This curious experiment proves, that the mouth projected rocks upwards of three thousand feet.

The whole of the eruptions recorded in this chronological statement belong solely to the three islands of Palma, Teneriffe, and Lanze-

\* Bory de St. Vincent, p. 296.

† “Three of these stones,” says Mr. Bory de St. Vincent, “took from twelve to fifteen seconds to rise till they were out of sight and fall back to the ground.” If such was the observation of Mr. Cologan, the result of the calculation would differ from that I have given; but the observer expressly says, in the manuscript in my possession: “De noche se observò con relox en mano y a muy corta distancia de la tercera bocca del volcan de Chahorra, el tiempo que desde su mas alto punto de elevacion hasta perderlas de vista en su caída, gastaban las piedras mas fáciles de distinguir y de très conque se hizo la experiencia, dos cayeron en diez segundas cada una y la otra en quinze.” Mr. Cologan observes, that the duration of the fall was even something more than fifteen seconds, because he could not keep the stones in sight till they touched the ground. This kind of observation is susceptible of great precision, as I was convinced from similar experiments, which I made during the eruption of Vesuvius in 1805.

rota \*. It is probable, that, previous to the sixteenth century, the other islands experienced also the effects of the volcanic fire. Some vague accounts were given me of an extinguished volcano in the centre of the isle of Ferro, and of another in the Great Canary, near Arguineguin. But it would be curious to know whether traces of subterranean fire are found in the calcareous formations of Fortaventura, or in the granites and mica-slates of Gomera.

The merely lateral action of the Peak of Teneriffe is a geological phenomenon, so much the more remarkable, as it contributes to make mountains, which are backed by the principal volcano, appear isolated. It is true, that in Etna and Vesuvius, the great flowings of the lavas do not proceed from the crater itself, and that the abundance of melted matter is generally in the inverse ratio of the height, at which the opening that ejects the lava, takes place. But at Vesuvius and Etna a lateral eruption constantly finishes by flashes of flame and by ashes, which issue from the crater, that is, from the summit of the mountain. At the Peak, this phenomenon has not taken place for ages : and yet recently, in the eruption of 1798, the crater remained quite inactive. It's bottom did not sink in, while at Vesuvius, as Mr. von Buch

\* Vieyra, Noticias. t. ii. p. 404 ; t. iii, p. 151, 238, 352, 356, and 516.

ingeniously observes, the greater or less depth of the crater is an infallible indication of the proximity of a new eruption.

I might terminate these geological sketches by discussing the nature of the combustible, which feeds, for so many thousands of years, the fire of the Peak of Teneriffe; I might examine whether it be sodium or potassium, the metallic basis of some earth, carburet of hydrogen, or pure sulphur combined with iron, that burns in the volcano; but wishing to limit myself to what may be the object of direct observation, I will not take upon me to solve a problem, for which we have not yet sufficient data. We are ignorant, whether we should conclude from the enormous quantity of sulphur contained in the crater of the Peak, that it is this substance which keeps up the heat of the volcano; or whether the fire, fed by a combustible of an unknown nature, effects merely the sublimation of the sulphur. What we learn from observation is, that in craters which are still burning sulphur is very rare; while all the ancient volcanoes finish by remaining true sulphur pits. We might presume, that in the former the sulphur is combined with oxygen, while in the latter it is merely sublimed; for nothing hitherto authorises us to admit, that it is formed in the interior of volcanoes, like ammonia and the neutral salts. When we were yet unacquainted

with sulphur, but as disseminated in the muriatiferous gypsum, and in the alpine limestone, we were almost obliged to suppose, that in every part of the Globe the volcanic fire acted on rocks of floetz or secondary formation; but recent observations have proved, that sulphur exists in great abundance in those primitive rocks, which so many phenomena indicate as the centre of the volcanic action. Near Alausi, on the summit of the Andes of Quito, I found an immense quantity in a bed of quartz, which formed a layer of mica-slate\*; and this fact is so much the more important, as it is in strict conformity with the observation of those fragments of ancient rocks which are thrown out untouched by the volcanoes.

\* In geognosy we must distinguish seven formations of sulphur, which are of a very different relative antiquity. The first belongs to the mica slate (Cordilleras of Quito); the second, to the transition gypsum (Bex in Switzerland); the third to the trappean porphyries (Antisana in America, Mont Serrat in the archipelago of the smaller Antilles, Mont d'Or in France); the fourth, to the Alpine limestone (Sicily); the fifth, to the muriatiferous gypsum, placed between the sand-stone and the alpine limestone (Thuringia); the sixth, to the gypsum which is more recent than chalk (Montmartre, near Paris); and the seventh, to clayey alluvions (Venejuelo, Lower Oroonoko, Mexico). It is scarcely necessary to observe, that, in this nomenclature, those small masses of sulphur, which are not contained in strata, but in the veins that traverse rocks of different formations, are left out of the question.



We have just considered the isle of Teneriffe under mere geological points of view ; we have seen the Peak towering amid fractured strata of basalt and mandelstein ; let us examine how these melted matters have been gradually adorned with vegetable clothing, what is the distribution of plants on the steep declivity of the volcano, and what is the aspect or physiognomy of vegetation in the Canary islands.

In the northern part of the temperate zone, the cryptogamous plants are the first, that cover the stony crust of the Globe. The lichens and mosses, that display their foliage beneath the snows, are succeeded by gramina, and other phanerogamous plants. This order of vegetation is different on the borders of the torrid zone, and in the countries between the tropics. We there find, it is true, whatever some travellers may have asserted, not only on the mountains, but also in humid and shady places, almost on a level with the ocean, *funaria*, *dicranum*, and *bryum* ; and these genera, among their numerous species, exhibit several, which are common to Lapland, the Peak of Teneriffe, and the Blue Mountains of Jamaica\*. Nevertheless, in gene-

\* This extraordinary fact, of which we shall speak hereafter, was first observed by Mr. Swarz. It was confirmed by the careful examination, which Mr. Willdenow made of our herbals, especially of the collection of cryptogamous plants, which we gathered on the tops of the Andes, in a re-

ral, it is not by mosses and lichens that vegetation in the countries near the tropics begins. In the Canary islands, as well as in Guinea, and on the rocky coasts of Peru, the first vegetables, that prepare the mould for others, are the succulent plants; the leaves of which, provided with an infinite number of orifices\* and cutaneous vessels, deprive the ambient air of the water it holds in solution. Fixed in the crevices of volcanic rocks, they form, as it were, the first layer of vegetable earth, with which the currents of lithoid lava are clothed. Wherever these lavas are scorified, and where they have a shining surface, as in the basaltic mounds to the north of Lanzerota, the unfolding of vegetation is extremely slow, and many ages may roll away before shrubs can take root. It is only when lavas are covered with tufa and ashes, the volcanic islands lose that appearance of nudity which marks their origin, and deck themselves with a rich and brilliant vegetation.

In it's present state, the island of Teneriffe, the *Chinerfe*† of the Guanches, exhibits five zones of plants‡, which we may distinguish by the names

gion of the world where organised beings totally differ from those of the rest of the old continent.

\* The bark pores of Mr. Decandolle, discovered by Gleichen, and figured by Hedwig.

† Of Chinerfe the Europeans have formed, by corruption, Tchineriffe and Teneriffe.

‡ I have partly sketched this picture of the vegetation of

of region of vines, region of laurels, region of pines, region of the ratama, and region of grasses. These zones are arranged in stages, one above the other, and occupy, on the steep declivity of the Peak, a perpendicular height of 1750 toises ; while fifteen degrees farther north, on the Pyrenees, the snows already descend to thirteen or fourteen hundred toises of absolute elevation. If the plants of Teneriffe do not reach the summit of the volcano, it is not because the perpetual snows \*, and the cold of the surrounding atmo-

the Canaries from the manuscript notes of Mr. Broussonet. When I published my first " Essay on the Geography of the Equinoctial Plants of the New World," I begged this distinguished naturalist, who had long resided at Mogadore, in the empire of Morocco, and at Santa Cruz, in Teneriffe, to communicate to me his ideas relative to the geographical distribution of plants in those countries. He yielded to my entreaty with that complaisance and urbanity, which he constantly exercised in his communications with learned foreigners.

\* Though the Peak of Teneriffe is covered with snow during the winter months only, it is nevertheless possible, that the volcano reaches the limit of the perpetual snows corresponding to it's latitude, and that the total absence of the snows in summer is owing to the isolated situation of the mountain in the midst of the seas, to the frequency of the ascending hot winds, or the elevated temperature of the ashes of the Piton but we are unable to solve these doubts, in the present state of our knowledge. From the parallel of the mountain of Mexico to that of the Pyrenees and the Alps, between the 20th and the 45th degrees, the curve of the perpetual snows has not been determined by any direct measure ; and as an

sphere, lay down limits which they cannot pass ; it is the scorified lava of the Malpays, the pow-

infinite number of these curves may be traced through the small number of points which are known to us under the latitudes of  $0^{\circ}$ ,  $20^{\circ}$ ,  $45^{\circ}$ ,  $62^{\circ}$ , and  $71^{\circ}$  north, calculation is a very imperfect substitute for observation. Without advancing any thing very positive, we may say, that it is probable in  $28^{\circ} 17'$  the limit of the snows is above 1900 toises. From the equator, where the snows begin at 2460 toises, that is near the height of Mont Blanc, to the twentieth of latitude, consequently to the limits of the torrid zone, the snows descend only a hundred toises ; now ought we to admit, that eight degrees farther, and in a climate which still bears almost the character of a climate of the tropics, this line already lowers four hundred toises ? Supposing even a lowering in arithmetical progression from the twentieth to the forty-fifth degree of latitude, a supposition which is contrary to known facts (*Rec. d'Obs. astron.*, vol. i, p. 134), the perpetual snows would not begin under the parallel of the Peak but at the height of 2050 toises above the level of the Ocean, consequently 550 toises higher than on the Pyrenees and in Switzerland. This result is supported also by other considerations. The mean temperature of the stratum of air, with which the snows are in contact during the summer, is, on the Alps, a few degrees below the point of congelation, and under the equator, a few degrees above it (*l. c. p.* 137). Admitting that, at 28 degrees and a half, this temperature is 0, we find according to the law of the decrement of heat, reckoning 98 toises to each centesimal degree, that the snows ought to exist at the height of 2058 toises above a plain, the mean temperature of which is 21 degrees, and consequently equal to that of the coasts of Teneriffe. This number is almost identical with that deduced from the hypothesis of a diminution in arithmetical progression. One of the high tops of the Sierra

dered and barren pumice stone of the Piton, which impede the migration of the plants toward the brink of the crater.

Nevada of Grenada, the Pico de Veleta, the absolute height of which is 1781 toises, is perpetually covered with snows : but the inferior limits of these snows not having been measured, this mountain, in the latitude of  $37^{\circ} 10'$ , gives us no information respecting the problem we wish to solve. With respect to the position of the volcano of Teneriffe, in the centre of an island of little extent, it does not appear, that this circumstance can cause a rising of the curve of the perpetual snows. If in islands the winters are less rigorous, the summers are less scorching ; and it is not so much on the mean temperature of the whole year, as on that of the summer months, that the height of the snows depends. On Etna the snows begin at 1500 toises, and even a little below ; which is extraordinary enough for a summit placed in  $37$  degrees and a half of latitude.

Towards the polar circle, where the heats of summer are tempered by the fogs that rise continually above the Ocean, the difference between the islands on the coasts and the interior of the country becomes extremely perceptible. In Iceland, for example, on the Osterjoeckull, in the sixty-fifth degree of latitude, the perpetual snows descend to four hundred and eighty two toises ; while in Norway, in the sixty-seventh, far from the coasts, in situations where the winters are much more rigorous, and where consequently the mean temperature of the year is less than in Iceland, the snows descend only to six hundred toises of height (*Leopold von Buch*, in the *Ann. of Gilb.* 1812, t. ii, p. 37 and 43). From these considerations it appears probable enough, that Bouguer and Saussure were deceived, when they admitted, that the Peak of Teneriffe reaches the constant inferior limit of the snows (*Figure de la terre*, p. 48, and *Voy. dans les Alpes*, t. iv, p. 103).



*The first zone*, that of the vines, extends from the seashore to two or three hundred toises of height; it is that which is most inhabited, and the only part carefully cultivated. In these low regions, at the port of Orotava, and wherever the winds have free access, the centigrade thermometer stands in winter, in the months of January and February, at noon, between fifteen and seventeen degrees; and the strongest heats of the summer do not exceed twenty-five or twenty-six degrees: they are consequently five or six degrees below the extremes, which the thermometer annually reaches at Paris, Berlin, and Petersburg. These results are taken from the observations made by Mr. Savaggi from 1795 to 1799. The mean temperature of the coasts of Teneriffe appears at least to rise to twenty-one degrees ( $16.8^{\circ}$  Réaumur), and their climate holds the medium between the climate of Naples, and that of the torrid zone. At the island of Madeira, the mean temperatures of the months of January and August are, according to Heberden, from  $17.7^{\circ}$  to  $23.8^{\circ}$ ; while at Rome they rise to  $5.6^{\circ}$  and  $26.2^{\circ}$ . But notwith-

We find this term for latitude  $28^{\circ} 17'$  at least at 1950 toises high, even in calculating it by interpolation between Etna and the volcanoes of Mexico. This matter will be made entirely clear, when we shall have measured the western part of Atlas, which near Morocco, in thirty degrees and a half of latitude, is covered with perpetual snows.

standing the extreme analogy observable between the climates of Madeira and Teneriffe, the plants of the first of these islands are generally less delicate to cultivate in Europe, than the plants of Teneriffe. The *cheiranthus longifolius* of Orotava, for instance, freezes at Montpellier, according to the observation of Mr. Decandolle ; while the *cheiranthus mutabilis* of Madeira passes the winter there in the open ground. The heats of summer are of less continuance at Madeira, than at Teneriffe.

The region of the vines exhibits, among it's vegetable productions, eight kinds of arborescent euphorbia ; mesembrianthema, which are multiplied from the Cape of Good Hope to the Peloponnesus ; the *cacalia kleinia*, the *dracæna*, and other plants, which in their naked and tortuous trunks, in their succulent leaves, and their tint of blueish green, exhibit features distinguishing the vegetation of Africa. It is in this zone, that the date tree, the plantain, the sugar cane, the India fig, the *arum colocasia*, the root of which furnishes the lower class with a nutritive fecula, the olive tree, the fruit trees of Europe, the vine, and corn are cultivated: The wheat is reaped from the end of March to the beginning of May : and the culture of the breadfruit tree of Otaheite, that of the cinnamon tree of the Moluccas, the coffee tree of Arabia, and the cocoa tree of America, have been tried with

success. On several points of the coast, the country assumes the character of a tropical landscape; and we recognize, that the region of the palms extends beyond the limits of the torrid zone. The chamærops and the date tree flourish in the fertile plains of Murviedro, on the coasts of Genoa, and in Provence, near Antibes, between the thirty-ninth and forty-fourth degrees of latitude: a few trees of the latter species, planted within the walls of the city of Rome, resist even a cold of  $2\cdot5^{\circ}$  below the freezing point. But if the south of Europe does not yet but feebly share in the gifts lavished by Nature on the zone of palms, the isle of Teneriffe, placed under the parallel of Egypt, southern Persia, and Florida, is already decorated with the greater part of the vegetable forms, that increase the majesty of the landscape in regions near the equator.

On reviewing the different tribes of indigenous plants, we regret the not having found trees with small pinnated leaves, and arborescent gramina. No species of the numerous family of the sensitive plants has pushed it's migrations as far as the archipelago of the Canary islands, while on both continents they have been discovered as far as the thirty-eighth and fortieth degrees of latitude. In America the *schranckia uncinata* of Willdenow \* advances even to the forests of

\* *Mimosa-horridula*. Michaux.

Virginia ; in Africa the gum-dropping acacia vegetates on the hills of Mogadore : in Asia, to the west of the Caspian Sea, Mr. von Biberstein saw the plains of Shirvan covered with the acacia *stephaniana*. If we more carefully examine the plants of the island of Lanzerota and Fortaventura, which are nearest the coasts of Morocco, we shall perhaps find a few mimosas among so many other plants of the African Flora.

The *second zone*, that of the laurels, contains the woody part of Teneriffe ; this is the region of the springs that rise up amidst a turf always verdant, and never parched with drought. Lofty forests crown the hills, that lead to the volcano, and in them find four species of laurel \*, an oak nearly resembling the *quercus Turneri* † of the mountains of Thibet, the *visnea mocanera*, the *myrica faya* of the Azores, a native olive (*olea excelsa*), which is the largest tree of this zone, two species of *sideroxylon*, the leaves of which are extremely beautiful, the *arbutus callicarpa*, and other evergreen trees of the family of myrtles. Bindweeds, and an ivy very different from that of Europe (*hedera canariensis*) entwine the trunks of the laurels ; at their feet vegetate a number-

\* *Laurus indica*, *l. foetens*, *l. nobilis*, and *l. Til*. With these trees are mingled the *ardisia excelsa*, *rhamnus glandulosus*, *erica arborea*, and *e. texo*.

† *Quercus canariensis*, Broussonet. (*Willd. Enum. Plant. Hort. Berol.* 1809, p. 975.)

less quantity of ferns \*, of which three species † alone descend as low as the region of the vines. The soil, covered with mosses and a tender grass, is enriched with the flowers of the golden campanula, the chrysanthemum pinnatifidum, the Canary mint, and several bushy species of hypericum ‡. Plantations of wild and grafted chestnut trees form a large border around the region of the springs, which is the greenest and most agreeable of the whole.

The *third zone* begins at nine hundred toises of absolute height, where the last group of arbutus, of myrica faya, and that beautiful heath known to the natives under the name of texo, appears. This zone, four hundred toises in breadth, is entirely filled by a vast forest of pines, among which mingles the juniperus cedro of Broussonet. The leaves of these pines are very long, stiff, and sprout sometimes by pairs, but oftener by threes in one sheath. As we had no opportunity of examining the fructification, we cannot say whether this species, which has the appearance of the Scotch fir, is really different from the eighteen species of pines, with which

\* Woodwardia radicans, asplenium palmatum, a. canariensis, a. latifolium, notholæna subcordata, trichomanes canariensis, t. speciosum, and davallia canariensis.

† Two acrostichums and the ophyoglossum lusitanicum.

‡ Hypericum canariense, h. floribundum, and h. glandulosum.



we are already acquainted on the old continent. A celebrated botanist, who by his excursions has rendered great services to the botanical geography of Europe, Mr. Decandolle, thinks, that the pine of Teneriffe is equally distinct from the *pinus atlantica* of the neighbouring mountains of Mogadore, and from the pine of Aleppo \*, which belongs to the basin of the Mediterranean, and does not appear to have passed the Pillars of Hercules. We have met with these last pines on the slope of the Peak, near twelve hundred toises above the level of the ocean. In the Cordilleras of New Spain, under the torrid zone, the Mexican pines reach as high as two thousand toises. Notwithstanding the similarity of structure, that exists between the different species of the same genus of plants, each of them requires a certain degree of temperature and rarity in the ambient air, to attain it's due growth. If in the temperate climates, and wherever snow falls, the constant heat of the soil is somewhat above the mean heat of the at-

\* *Pinus halepensis*. Mr. Decandolle observes, that this species, which is not found in Portugal, but grows on the Mediterranean side of France, Spain, and Italy, in Asia Minor, and in Barbary, would be better named *pinus mediterranea*. It composes the principal part of the forests of pines in the south-east of France, where Gouan and Gerard have confounded it with the *pinus sylvestris*. It comprehends the *pinus halepensis*, Mill., Lamb., and Desfont., and the *pinus maritima*, Lamb.

mosphere, it is probable, that at the height of Portillo, the roots of the pines draw their nourishment from a soil, in which, at a certain depth, the thermometer rises at most to nine or ten degrees.

The *fourth and fifth zones*, the regions of the retama and the gramina, occupy heights equal to the most inaccessible summits of the Pyrenees. It is the sterile part of the island, where heaps of pumice stone, obsidian, and broken lava, form impediments to vegetation. We have already spoken of those flowery tufts of alpine broom (*spartium nubigenum*), that form oases amidst a vast sea of ashes. Two herbaceous plants, the *scrofularia glabrata*, and the *viola cheiranthifolia*, advance even to the Malpays. Just above a turf scorched by the heat of an African sun, an arid soil is overspread by the *cladonia pascchalis*, to which the herdsmen often set fire, that rolls to considerable distances. Toward the summit of the Peak, the *urceolarea*, and other plants of the family of the lichens, labour at the decomposition of the scorified matter. By this unceasing action of organic forces the empire of Flora extends itself over islands ravaged by volcanoes.

In traversing the different zones of the vegetation of Teneriffe, we see that the whole island may be considered as a forest of laurels, arbutus, and pines, of which the border has scarcely been

cleared, and which contains in it's centre a naked and rocky soil, unfit either for pasturage or cultivation. Mr. Broussonet observes, that the archipelago of the Canaries may be divided into two groups of islands. The first contains Lanzarote and Fortaventura, the second Teneriffe, Canary, Gomera, Ferro, and Palma. The appearance of the vegetation essentially differs in these two groups. The eastern islands, Lanzarote and Fortaventura, consist of extensive plains and mountains of little elevation; they have very few springs, and bear the appearance, still more than the other islands, of having been separated from the continent. The winds blow in the same direction, and at the same periods: the *euphorbia mauritanica*, the *atropa frutescens*, and the arborescent *sonchus*, vegetate there in the loose sands, and serve, as in Africa, for food to camels. The western group of the Canaries presents a more elevated soil, more woody, and watered by a greater number of springs.

Though the whole archipelago contains several plants found in Portugal \*, in Spain, at the

\* Mr. Willdenow and myself found, among the plants of the Peak of Teneriffe, the beautiful *satyrium diphyllum*, (*orchis cordata*, Willd.), which Mr. Link discovered in Portugal. The Canaries have, in common with the Flora of the Azores, not the *dicksonia culcita*, the only arborescent heath found at the thirty-ninth degree of latitude, but the *asplenium palmatum*, and the *myrica faya*. This tree is met with in Portugal, in a wild state. Count Hoffmannsegg has seen

Azores, and in the north-west of Africa, a great number of species, and even of genera, are peculiar to Teneriffe, to Porto Santo, and Madeira. Such are the *mocanera*, the *plocama*, the *bosea*, the *canarina*, the *drusa*, and the *pittosporum*. A form which may be called northern, that of the cruciform plants \*, is already much rarer in the Canaries, than in Spain and in Greece. Still farther to the south, in the equinoctial regions of both continents, where the mean temperature of the air rises above twenty-two degrees, the cruciform plants are scarcely ever to be seen.

A question highly interesting to the history of the progressive display of organization on the Globe has been very warmly discussed in our own times, that of ascertaining whether the polymorphous plants are more common in the

very old trunks of it; but it was doubtful whether it was indigenous, or imported into this part of our continent. In reflecting on the migrations of plants, and on the geological possibility, that lands sunk in the ocean may have heretofore united Portugal, the Azores, the Canaries, and the chain of Atlas, we conceive, that the existence of the *myrica faya* in western Europe is a phenomenon at least as striking as that of the pine of Aleppo would be at the Azores.

\* Among the small number of cruciform species contained in the Flora of Teneriffe, we shall here mention *cheiranthus longifolius*, l'Herit. ; *ch. frutescens*, Vent. ; *ch. scoparius*, Brouss. ; *erysimum bicornis*, Aiton ; *crambe strigosa*, and *c. lævigata*, Brouss.

volcanic islands. The vegetation of Teneriffe is unfavourable to the hypothesis, that nature in new countries appears less subjected to constant forms. Mr. Broussonet, who resided so long at the Canaries, asserts, that the variable plants are not more common there than in the south of Europe. Ought it not to be presumed, that the polymorphous species, which are so abundant in the Isle of Bourbon, are owing rather to the nature of the soil, and to the climate, than to the newness of the vegetation ?

I have now given a physical sketch of the island of Teneriffe ; I have endeavoured to lay down precise notions respecting the geological constitution of the Canaries, the geography of plants peculiar to this archipelago, and their grouping at different heights above the level of the ocean. Though I flatter myself with having thrown some light on objects, which have been so often discussed by other travellers, I think nevertheless, that the natural history of this archipelago still offers a vast field to inquiry. The commanders in scientific expeditions, of which England, France, Spain, Denmark, and Russia have furnished such brilliant examples, have in general been too hasty in quitting the Canaries. They have imagined, that these islands have been sufficiently described, because they are so nearly bordering on Europe ; they have forgotten, that, in a geological point of view,



the interior of New Holland is not more unknown, than the rocks of Lanzerota and Gomera, of Porto Santo and Terceira. We every year see a great number of naturalists traverse without any determined end the most frequented parts of Europe. Let us hope, that some among them, influenced by a love of science, and capable of pursuing a plan of several years, will devote themselves to the examination of the archipelago of the Azores, Madeira, the Canaries, Cape Verd Islands, and the north-west coast of Africa. By comparing observations made under the same point of view, in the Atlantic islands, and on the neighbouring continent, we shall attain exact information with respect to geology, and the geography of animals and plants.

Before we take leave of the old world to pass into the new, I must speak of a subject which inspires a still greater interest, because it belongs to the history of man, and to those fatal revolutions, which have swept off whole tribes from the face of the earth. We inquire at the isle of Cuba, at St. Domingo, and in Jamaica, where is the abode of the primitive inhabitants of those countries? We ask at Teneriffe what is become of the Guanches, whose mummies alone, buried in caverns, have escaped destruction? In the fifteenth century, almost all the mercantile nations, especially the Spaniards and the Portuguese, sought for slaves at the Canary islands,

as we seek them at present on the coast of Guinea\*. The Christian religion, which in it's origin was so highly favourable to the liberty of mankind, served as a pretext to the cupidity of Europeans. Every individual, made prisoner before he received the rite of baptism, was a slave. At this period, no attempt had yet been made to prove, that the blacks were an intermediary race between men and animals. The swarthy Guanche and the African negro were simultaneously sold in the market of Seville, without a question whether slavery ought to weigh only on men with a black skin and frizzled hair.

The archipelago of the Canaries was divided into several small states hostile to each other. Oftentimes the same island was subject to two independent princes, as happens in the islands of the South Sea, and wherever society is not highly advanced. The trading nations, influenced by that hideous policy which they still exercise on the coast of Africa, kept up intestine warfare. One Guanche then became the property of another, who sold him to the Europeans; several, who preferred death to slavery, killed themselves and their children. It is in this manner that the population of the Canaries

\* The Spanish historians speak of expeditions made by the Huguenots of La Rochelle to carry off Guanche slaves. I have some doubt respecting these expeditions, which would have taken place posterior to the year 1530.

had considerably suffered by the slave trade, by the depredations of pirates, and especially by a long period of carnage, when Alonzo de Lugo completed their conquest. What remained of the Guanches perished mostly in 1494, in the terrible pestilence called the *modorra*, which was attributed to the quantity of dead bodies left exposed to the air by the Spaniards after the battle of la Laguna. When a semibarbarous nation, robbed of its property, is compelled to live in the same country with a polished people, it seeks a retreat on the mountains and in the forests. This is the only refuge left to the choice of an islander. The nation of the Guanches was therefore extinct at the beginning of the seventeenth century ; a few old men only were found at Candelaria and Guimar.

It is however consoling to find, that the whites have not always disdained to intermarry with the natives ; but the Canarians of the present day, whom the Spaniards denote by the familiar title of *Islennos*, have very powerful motives for denying this mixture. In a long series of generations time effaces the characteristic marks of a race ; and as the dependants of the Andalusians settled at Teneriffe are themselves of a dark complexion, we may conceive, that the intermarriages cannot have produced a perceptible change in the color of the skins of the whites. It is very certain, that no native of pure race

exists in the whole island ; and some travellers, who may be otherwise relied on, are mistaken, when they assert, that their guides to the Peak were some of those slender and nimble footed Guanches. It is true, that a few Canarian families boast of their relationship to the last shepherd king of Guimar ; but these pretensions do not rest on very solid foundations ; and are renewed from time to time, when some Canarian, of a more dusky hue than his countrymen, is prompted to solicit a commission in the service of the king of Spain.

A short time after the discovery of America, when Spain was at the highest degree of it's splendor, the gentle character of the Guanches was the fashionable topic, as we chaunt in our times the Arcadian innocence of the inhabitants of Otaheite. In both these pictures, the coloring is more gaudy than appropriate. When nations, wearied with mental enjoyments, behold nothing in the refinement of manners but the germe of depravity, they are flattered with the idea, that in some distant region, in the first dawn of civilization, infant societies enjoy pure and perpetual felicity. To this sentiment Tacitus owed a part of his success, when he sketched for the Romans, subjects of the Cæsars, the picture of the manners of the inhabitants of Germany. The same sentiment gives an ineffable charm to the narrative of those travellers,

who, at the close of the last century, visited the islands of the Pacific Ocean.

The inhabitants of those islands, too much vaunted, though heretofore anthropophagi, resemble, under more than one point of view, the Guanches of Teneriffe. We see both nations groaning under the yoke of feudal government. Among the Guanches this institution, which facilitates and renders a state of warfare perpetual, was sanctioned by religion. The priests declared to the people, "The great Spirit, Achaman, created first the nobles, the *achimenceys*, to whom he distributed all the goats, that exist on the face of the Earth. After the nobles, Achaman created the plebeians, *achicaxnas*. This younger race had the boldness to petition also for goats; but the supreme being answered, that this race was destined to serve the nobles, and that they had need of no property." This tradition was made, no doubt, to please the rich vassals of the shepherd kings. Thus the *faycan*, or high priest, exercised the right of conferring nobility; and the law of the Guanches expressed, that every achimencey, who degraded himself by milking a goat with his own hands, lost his title to nobility. This law does not remind us of the simplicity of the Homeric age. We are astonished to see the useful labours of agriculture, and of a pastoral life, exposed to contempt at the very dawn of civilization.



The Guanches, famed for their tall stature, were the Patagonians of the old world; and historians exaggerated the muscular force of the Guanches, as, previous to the voyage of Bougainville and Cordoba, a colossal form was conferred on the tribe, that inhabited the southern extremity of America. I never saw Guanche mummies but in the cabinets of Europe; at the period of my journey, they were very scarce; a considerable number, however, might be found, if miners were employed to open the sepulchral caverns, which are cut in the rock on the eastern slope of the Peak, between Arico and Guimar. These mummies are in a state of desiccation so singular, that whole bodies, with their integuments, frequently do not weigh above six or seven pounds; or a third less than the skeleton of an individual of the same size, recently stripped of the muscular flesh. The conformation of the skull has some slight resemblance to that of the white race of the ancient Egyptians; and the incisive teeth of the Guanches are blunted, like those in the mummies found on the banks of the Nile. But this form of the teeth is owing to art alone; and on examining more carefully the physiognomy of the ancient Canarians, able anatomists\* have recognised in the cheek bones, and the lower jaw, perceptible differences from

\* *Blumenbach, Decas quinta Collect. suæ Craniorum diversarum Gentium illustr.* 1808, p. 7.

the Egyptian mummies. On opening those of the Guanches, remains of aromatic plants are discovered, among which the chenopodium ambrosioides is constantly perceived : the corpses are often decorated with small laces, to which are hung little discs of baked earth, that appear to have served as numerical signs, and resemble the *quippees* of the Peruvians, the Mexicans, and the Chinese.

As the population of islands is in general less exposed to the effect of migrations than that of continents, we may presume, that, in the time of the Carthaginians and the Greeks, the Archipelago of the Canaries was inhabited by the same race of men, as were found by the Norman and Spanish conquerors. The only monument that can throw some light on the origin of the Guanches is their language ; but unhappily there are not above a hundred and fifty words remaining, several of which express the same object, according to the dialect of the different islanders. Independent of these words, which have been carefully noted, there are still some valuable fragments existing in the names of a great number of hamlets, hills, and valleys. The Guanches, like the Biscayans, the Hindoos, the Peruvians, and all the primitive nations, had named the places after the quality of the soil they cultivated, the shape of the rocks, the ca-

verns that gave them shelter, and the nature of the tree that overshadowed the springs.

It has been long imagined, that the language of the Guanches had no analogy with the living tongues ; but since the travels of Hornemann, and the ingenious researches of Marsden and Venturi, have drawn the attention of the learned to the Berbers, who like the Sarmatic tribes, occupy an immense extent of country in the north of Africa, we find, that several Guanche words have common roots with words of the Chilha and Gebali dialects \*. We shall cite for instance the words :

Heaven, <i>in Guanche</i> —	Tigo ;	<i>in Berberic</i> , Tigot.
Milk	Aho ;	Acho.
Barley	Temasen	Tomzeen.
Basket	Carianas	Carian.
Water	Aenum	Anan.

I doubt whether this analogy is a proof of a common origin ; but it is an indication of the ancient connexion between the Guanches and Berbers, a tribe of mountaineers, in which the Numidians, the Getuli, and the Garamanti are confounded, and who extend themselves from the eastern extremity of Atlas by Harutsch and Fezzan, as far as the oasis of Siwah and Augela. The natives of the Canary Islands called themselves Guanches from *guan*, man ; as the Ton-

\* Adelung und Vater, Mithridates, t. iii, p. 60.

guese call themselves *bye* and *donki*, which have the same signification as *guan*. Besides, the nations who speak the Berberic language are not all of the same race ; and the description, which Scylax gives in his Periplus of the inhabitants of Cerne, a shepherd people of a tall stature and long hair, reminds us of the features which characterise the Canary Guanches.

The greater attention we give to the study of languages in a philosophical point of view, the more we must observe, that no one of them is entirely distinct; the language of the Guanches \* would appear still less so, had we any data respecting it's mechanism and grammatical construction ; two elements more important than the form of words, and the identity of sounds. It is the same with certain idioms, as with those organized beings, that seem to shrink from all classification in the series of natural families.

\* According to the researches of Mr. Vater, the Guanche language offers the following analogies with the languages of nations very remote from each other : *dog* among the American Hurons, *aguienon* ; among the Guanches, *aguyan* ; *man*, among the Peruvians, *cari* ; among the Guanches, *coran* ; *king*, among the African Mandingoes, *monso* ; among the Guanches, *monsey*. The name of the island of Gomera is found in that of Gomer, which designates a tribe of Berbers (Vater, *Untersuch. ueber Amerika*, p. 170). The Guanche words *Alcorac*, *God*, and *almogaron*, *temple*, seem to be of Arabic origin ; at least in the latter tongue *almoharram* signifies *sacred*.

Their isolated state is only so in appearance ; for it ceases, when, on embracing a greater number of objects, we come to discover the intermediate links. The learned, who find Egyptians wherever there are mummies, hieroglyphics, or pyramids, will imagine, perhaps, that the race of Typhon was united to the Guanches by the Berbers, real Atlantics, to whom belong the Tibboes and the Tuarycks of the Desert \*; but it is sufficient here to observe, that this hypothesis is supported by no analogy† between the Berberic and Coptic languages, which are justly considered as a remnant of the ancient Egyptian.

The people who succeeded the Guanches descended from the Spaniards, and in a less degree from the Normans. Though these two races have been exposed during three centuries past to the same climate, the latter is distinguished by a whiter skin. The descendants of the Normans inhabit the valley of Teganana, between Punta de Naga and Punta de Hidalgo. The names of Grandville and Dampierre are still pretty common in this district. The Canarians are a moral, sober, and religious people; of a less industrious character at home, than in foreign countries. A roving and enterprising

\* Voyage de Hornemann du Cairo à Mourzouk, t. ii, p. 406.

† Mithridates, t. iii, p. 77.



disposition leads these islanders, like the Biscayans and Catalonians, to the Philippines, to the Marian islands, to America, and wherever there are Spanish settlements, from Chili and la Plata to New-Mexico. To them we are in a great measure indebted for the progress of agriculture in those colonies. The whole Archipelago does not contain 160,000 inhabitants, and the *Islennos* are perhaps more numerous in the new continent, than in their own country. The following table indicates whatever relates to the statistics of this country.

Archipelago of the Canaries.	Surface in nau- tical square leagues.	Absolute population.				Relative population, or number of inhabit- ants to each square league in 1790.
		1678	1745	1768	1790	
Teneriffe . . . .	73	49,112	60,218	66,354	70,000	958
Fortaventura . . . .	63		7,382	8,863	9,000	142
Grand Canary . . . .	60	20,458	33,864	41,082	50,000	833
Palma . . . .	27	13,892	17,580	19,195	22,600	837
Lanzerota . . . .	26		7,210	9,705	10,000	384
Gomera . . . .	14	4,373	6,251	6,645	7,400	528
Ferro . . . .	7	3,297	3,687	4,022	5,000	714
Total . . . .	270		136,192	155,866	174,000	644

The enumerations of 1678, 1745, and 1768, have been published by Vieyra. The estimation of 1790 is by Mr. Ledru. The total population, according to Lord Macartney, was 196,500 ; of which there were 100,000 at Teneriffe, 40,000 at Canary, and 30,000 at Palma. The surfaces have been calculated for the first time, and very accurately, by Mr. Oltmanns\*, from the chart of Borda and Varela. The vintage of Teneriffe yields from 20 to 24,000 pipes, 5000 of which are malmsey. The annual exportation of wine is from 8 to 9000 pipes. The amount of the harvest in the whole of the Archipelago in wheat is 45,000 fanegas, of a hundred pounds each. In ordinary years this crop is sufficient for the consumption of the inhabitants, who otherwise live on maize, potatoes, and French beans, *frisoles*. The cultivation of the sugar-cane and cotton is of little importance ; the principal objects of commerce are wine, brandy, archil, and soda. The gross amount of the revenue, including the tax on tobacco, is 240,000 piastres.

\* Extent of the surface of the Canaries more accurately expressed in geographic leagues of 15 to a degree : Teneriffe,  $41\frac{3}{8}$  ; Fortaventura,  $35\frac{1}{4}$  ; Canary,  $33\frac{7}{8}$  ; Palma,  $15\frac{1}{4}$  ; Lanzerota,  $14\frac{3}{8}$  ; or, including the small neighbouring islands,  $15\frac{3}{8}$  ; Gomera, 8 ; and Ferro,  $3\frac{7}{8}$  : total  $153\frac{1}{2}$ . It is astonishing, that Mr. Hassel, in his excellent work on the statistics of Europe, gives the Canaries a population of 420,000 inhabitants, and an extent of 358 square German miles. (*Stat. Umriss. Heft. 1. 17.*)

I shall not enter into any discussions of political economy relative to the importance of the Canary islands to the trading nations of Europe. Having long employed myself in statistical researches on the Spanish colonies, and being on terms of intimacy with persons who had held places of importance at Teneriffe, I had an opportunity, during my abode in Caraccas and at the Havannah, of collecting considerable information respecting the commerce of Santa Cruz and Orotava. But several distinguished persons having since visited the Canaries, they have obtained the same means of information as myself; and I do not hesitate to strike out from my narrative, what has been explained, with greater precision, in works that have preceded mine. I shall here confine myself to a few considerations, which will terminate the sketch I have just given of the Archipelago of the Canaries.

These islands have undergone the same fate as Egypt, the Crimea, and many other countries, respecting which travellers, who are anxious to elevate and surprise by contrasts, have been extravagant both in their praise and their blame. Some, landing at Orotava, describe Teneriffe as the garden of the Hesperides, and celebrate the amenity of the climate, the fruitfulness of the soil, and the richness of the cultivation; others, forced to sojourn at Santa Cruz, behold nothing in these Fortunate Islands but a country, naked, barren,

and inhabited by a stupid and miserable race. It appeared to me, that in this archipelago, as in all mountainous and volcanic countries, Nature has been very unequal in the distribution of her gifts. The Canaries are generally deficient in water ; but wherever there are springs, artificial irrigations, or plentiful rains, the soil is highly fertile. The lower class of the people is laborious ; but it's industry is more active in distant colonies, than at Teneriffe, where it meets with obstacles, which a wise administration might progressively remove. Emigration would be diminished, if the uncultivated demesne lands were distributed among private persons, those which are annexed to the *majorats* of the great families were sold, and feudal rights were gradually abolished.

The present population of the Canaries undoubtedly appears inconsiderable, when compared with that of several countries of Europe. The island of Malta, the industrious inhabitants of which cultivate a rock almost destitute of mould, is seven times less than Teneriffe, and yet has twice the population : but writers, who are fond of painting in vivid colors the depopulation of the Spanish colonies, and who attribute the cause to the ecclesiastical hierarchy, forget that in every place, since the reign of Philip V, the number of inhabitants has obtained, in a greater or less degree, a rapid increase. The relative population is already greater in the Ca-



naries, than in both Castiles, in Estramadura, and in Scotland. The whole archipelago exhibits a mountainous country, the extent of which is a seventh less than the surface of the island of Corsica : it supplies, however, the same number of inhabitants.

Though the islands of Lanzerota and Fortaventura, which are the least populous, export corn, while Teneriffe does not produce two thirds of it's consumption, we must not conclude, that in this last island the number of inhabitants cannot increase for want of subsistence. The Canary islands are still remote from feeling the evils, that arise from too considerable a population, and of which Mr. Malthus has unfolded the causes with so much precision and knowledge. The misery of the people has considerably diminished, since the cultivation of potatoes\* has been introduced, and since they have begun to sow more maize, than wheat and barley.

The inhabitants of the Canaries exhibit traits characteristic of a people, who are at the same time mountaineers and islanders. In order to estimate them truly, it is not enough to behold them in their own country, where powerful obstacles prevent the display of industry ; we must study them in the plains of the province of Ca-

\* Tessier and Desautoy, on the Agriculture of the Canaries. *Mem. de l'Inst*, t. i, p. 250 et 279.

raccas, on the ridge of the Andes, in the burning plains of the Philippine islands, and wherever isolated in uninhabited countries they have had occasion to display that energy and activity which are the true riches of a planter.

The Canarians are fond of considering their country as forming part of European Spain, and they have added some portion to the riches of Castilian literature. The names of Clavijo, author of the *Pensador Madritense*, of Vieyra, Yriarte, and Betancourt, are honourably distinguished in the scientific and in the literary world. The Canarians are endowed with that liveliness of imagination, which characterizes the inhabitants of Andalusia and Grenada ; and we may be led to hope, that, at some future period, the Fortunate Islands, like every other climate of the Globe, either where man reposes on the lavish bounties of Nature, or shrinks from the severity of her frown, will inspire the muse of some native poet.



JOURNEY  
TO THE  
EQUINOCTIAL REGIONS  
OF  
THE NEW CONTINENT.

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CHAPTER III.

*Passage from Teneriffe to the coasts of South America.—The Island of Tobago.—Arrival at Cumana.*

WE left the road of Santa Cruz the evening of the 25th of June, and directed our course toward South America. The wind blew strong from the north-east, and the waves were short, and broken from the opposition of the currents. We soon lost sight of the Canary islands, the lofty mountains of which were covered with a reddish vapour. The Peak alone appeared from time to time in the breaks, as the wind, which must have blown strong in the upper regions of

the air, dispersed at intervals the clouds that enveloped the Piton. We felt for the first time how strong are the impressions left on the mind from the aspect of those countries placed on the limits of the torrid zone, and in which nature appears at once so rich, so various, and so majestic. Our stay at Teneriffe had been very short, and yet we withdrew from the island as if it had been for a long time our home.

Our passage from Santa Cruz to Cumana, the most eastern part of the New Continent, was very fine. We cut the tropic of Cancer the 27th, and though the Pizarro was not a very good sailer, we ran in twenty days the space of nine hundred leagues, which separates the coasts of Africa from those of the New Continent. We passed fifty leagues west of Cape Bajador, Cape Blanco, and the islands of Cape Verd. A few land birds, which had been driven to sea by the impetuosity of the wind, followed us for several days. If we had not exactly known, by our time keepers, our longitude, we should have been tempted to think, that we were very near the coast of Africa.

Our course was such as is taken by all vessels destined for the Antilles since the first voyage of Columbus. The latitude diminished rapidly, almost without gaining in longitude, from the parallel of Madeira to the tropic. When we reach the zone, where the trade winds are constant, we



cross the ocean from east to west, on a calm and pacific sea, which Spanish sailors call the Ladies Gulf, *el Golfo de las Damas*. We found, as all do who frequent those latitudes, that, in proportion as we advance toward the west, the trade winds, which were at first east-north-east, fix to the east.

Those winds, the most generally adopted theory of which is explained in a celebrated treatise of Halley\*, are a phenomenon much more complicated† than the greater number of naturalists admit. In the Atlantic Ocean, the longitude as well as the declination of the sun, influences the direction and limits of the trade winds. On the side of the New Continent, in both hemispheres,

\* The existence of an upper current of air, which blows constantly from the equator to the poles, and of a lower current, which blows from the poles to the equator, had already been admitted, as Mr. Arago has shown, by Hooke. The ideas of the celebrated English naturalist are developed in a discourse on Earthquakes published in 1686. "I think (adds he,) that several phenomena, which are presented by the atmosphere and the ocean, especially the winds, may be explained by the polar currents." (Hooke's Posthumous Works, p. 364.) This curious passage is not cited by Halley (Phil. Trans. vol. xxxix, p. 58). On the other hand, Hooke, speaking directly of the trade winds (Post. Works, p. 88 and 363), adopts the erroneous theory of Galileo, who admits a difference of velocity between the movement of the Earth and that of the air.

† Mém. de l'Acad. 1760. p. 18. D'Alembert, sur les Causes gén. des Vents, p. 5.

these limits pass the tropics eight or nine degrees; while in the vicinity of Africa the variable winds reign far beyond the parallel of 28 or 27 degrees. It is to be regretted, on account of the progress of meteorology and navigation, that the changes, which the currents of the equinoctial atmosphere in the Pacific Ocean undergo, are much less known, than the variation of these same currents in a sea that is narrower, and influenced by the proximity of the coasts of Guinea and Brazil. Navigators have known for ages past, that in the Atlantic Ocean the equator does not coincide with the line which separates the trade winds of the north-east from the general winds of the south-east. This line, as Halley\* has very well observed, is at the third or fourth degree of north latitude; and if it's position be the effect of a longer abode of the Sun in the northern hemisphere, it tends to prove, that the temperatures of the two hemispheres† are in the ratio of eleven to nine. We shall see farther on in this work, when we treat of the part of the atmosphere which extends over the

\* Phil. Trans. vol. xvi, p. 154. Ulloa, Conversaciones, p. 109.

† Prevost, on the limits of the trade winds. Journ. de Phys. t. xxxviii, p. 369. Supposing with Æpinus, that the southern hemisphere is only one fourteenth colder than the northern, the calculation gives, for the northern limit of the E. S. E. trade winds, the parallel of  $1^{\circ} 28'$ .

South Sea, that to the west of America the trade winds of the south-east reach to a less distance beyond the equator, than they do in the Atlantic Ocean. In fact the difference, with which the strata of air flow back from the two poles toward the equator, cannot be the same in every degree of longitude, that is to say, on points of the Globe, where the continents have very different breadths, and where they stretch away more or less toward the poles.

It is known, that in the passage from Santa Cruz to Cumana, as in that from Acapulco to the Philippine islands, the sailors are scarcely ever under the necessity of touching the sails. We pass those latitudes, as if we were descending a river, and we might deem it no hazardous undertaking, if we made the voyage in an open boat. Farther west, on the coast of St. Martha, and in the Gulf of Mexico, the trade wind blows impetuously, and renders the sea very stormy\*.

The wind fell gradually the farther we removed from the African coasts: it was sometimes smooth water for several hours, and these short calms were regularly interrupted by electrical phenomena. Black thick clouds with

\* The Spanish sailors call the rough trade winds at Carthagena in the West Indies *los brisotes de Santa Martha*; and in the Gulf of Mexico, *las brizas pardas*. These latter winds are accompanied with a gray and cloudy sky.

strong outlines rose on the east, and it seemed as if a squall would have forced us to hand our topsails; but the breeze freshened anew, there fell a few large drops of rain, and the storm was dispersed without our hearing any thunder. It was curious to observe, during this time, the effect of several black, isolated, and very low clouds, which passed the zenith. We felt the force of the wind augment or diminish progressively, according as small bodies of vesicular vapour approached or receded, while the electrometers, furnished with a long metallic rod and lighted match, showed no change of electric tension in the lower strata of the air. It is by means of these squalls, which alternate with dead calms, that the passage from the Canary islands to the Antilles or southern coasts of America is made in the months of June and July. In the torrid zone, the meteorological phenomena follow each other in a very uniform manner; and the year 1803 will be for a long time memorable in the annals of navigation, because several vessels coming from Cadiz to the Caracas were forced to lie to in the fourteenth degree of latitude, and the forty-eighth degree of longitude, on account of a very violent wind, which blew for several days from the north-north-west. What an extraordinary interruption must we suppose in the play of the aerial currents, to explain a cross wind, which without doubt must

have deranged at the same time the regularity of the horary oscillations of the barometer !

Some Spanish navigators have lately proposed going to the West Indies and the coasts of Terra Firma, by a different course from that which had been taken by Christopher Columbus. They advise, instead of steering directly to the south in search of the trade winds, to change both latitude and longitude, in a diagonal line from Cape St. Vincent to America. This method, which shortens the way, cutting the tropic nearly twenty degrees west of the point where it is commonly cut by the pilots, has several times been successfully followed by Admiral Gravina. This experienced seaman, who perished gloriously at the battle of Trafalgar, arrived in 1802 at St. Domingo, by the oblique passage, several days before the French fleet, though orders of the court of Madrid would have forced him to enter Ferrol with his squadron, and stop there some time.

This new system of navigation shortens the passage from Cadiz to Cumana a twentieth; but as the tropic is attained only at the longitude of forty degrees, the chance of meeting with contrary winds, which blow sometimes from the south, and at other times from the south-west, is more unfavorable. In the old system, the disadvantage of making a longer passage is compensated by the certainty of finding the trade



winds in a shorter space of time, and keeping them the greater part of the passage. At the time of my abode in the Spanish colonies, I witnessed the arrival of several merchant ships, which the fear of privateers had determined to choose the oblique course, and that had a very short passage; it is only after repeated trials, that we can decide with certainty on an object, at least as important as the choice of the meridian, at which the equator should be cut in the navigation from Europe to Buenos Ayres or Cape Horn.

Nothing equals the beauty and mildness of the climate of the equinoctial region on the ocean. While the trade wind blew strongly, the thermometer kept at 23 or 24 degrees in the day, and at 22 or 22·5 degrees during the night. To feel the full charm of these happy climates bordering on the equator, the passage from Acapulco or the coasts of Chili to Europe should be undertaken in a very rough season. What a contrast between the tempestuous seas of the northern latitudes, and the regions where the calm of nature is never disturbed! If the return from Mexico or South America to the coasts of Spain were as expeditious and as agreeable as the passage from the old to the new continent, the number of Europeans settled in the colonies would be much less considerable than it is at present. The sea which surrounds the

Azores and the Bermuda islands, and which is traversed in returning to Europe by the high latitudes, is called by the Spaniards by the singular name of *Golfo de las Yeguas* (the Mares' Gulf). Colonists who are not accustomed to the sea, and who have led solitary lives in the forests of Guiana, the savannahs of the Caraccas, or the Cordilleras of Peru, dread the neighbourhood of the Bermudas more than the inhabitants of Lima fear at present the passage round Cape Horn. They exaggerate the danger of a navigation which is perilous only in the winter. They defer from one year to another the execution of a project which appears hazardous, and death very often surprises them in the midst of the preparations which they make for their return.

To the north of the Cape Verd islands we met with great masses of floating sea-weeds. They were the tropic grape, *fucus natans*, which grows on submarine rocks, only from the equator to the fortieth degree of north and south latitude. These weeds seem to indicate the existence of currents in this place, as well as to the southwest of the banks of Newfoundland. We must not confound the latitudes abounding in scattered weeds with these banks of marine plants, which Columbus compares to extensive meadows, the view of which struck with terror the crew of the *Santa Maria* in the forty-second

degree of longitude. I am assured from the comparison of a great number of journals, that in the basin of the Atlantic Northern Ocean, there exist two banks of weeds very different from each other. The most extensive is a little west of the meridian of Fayal, one of the Azores, between the twenty-fifth and thirty-sixth degrees of latitude\*. The temperature of the Ocean in those latitudes is from sixteen to twenty degrees; and the north winds, which sometimes reign there very tempestuously, drive floating isles of sea-weed down into the low latitudes as far as the parallels of twenty-four and even twenty degrees. The vessels which return to Europe, either from Montevideo or the Cape of Good Hope, cross these banks of fucus, which the Spanish pilots consider as at an equal distance from the Antilles and Canaries; and they serve the less instructed mariner to rectify his longitude. The second bank of fucus is but

\* It appears that Phœnician vessels came "in thirty days sail, with an easterly wind," to the *weedy sea*, which the Portuguese and Spaniards call *mar de zargasso*. I have shown in another place, that the passage of Aristotle, *De Mirabil. ed. Duval*, p. 1157, can scarcely be applied to the coasts of Africa, like an analogous passage of the Periplus of Scylax. *Tableaux de la Nature*, t. i, p. 98. Supposing that this sea, full of weeds, which impeded the course of the Phœnician vessels, was the *mar de zargasso*, we need not admit, that the ancients traversed the Atlantic beyond thirty degrees of west longitude from the meridian of Paris.

little known ; it occupies a much smaller space in the twenty-second and twenty-sixth degrees of latitude, eighty leagues west of the meridian of the Bahama islands. It is found on the passage from the Caiques to the Bermudas.

Though a species of sea-weeds \* has been seen with stems eight hundred feet long, the growth of these marine cryptogamia being extremely rapid, it is not less certain, that, in the latitudes we have just described, the fuci, far from being fixed to the bottom, float in separate masses on the surface of the water. In this state, the vegetation can scarcely continue a longer time than it would do in the branch of a tree torn from it's trunk ; and in order to explain how moving masses are found for ages in the same position, we must admit, that they owe their origin to submarine rocks, which, placed at forty or sixty fathoms depth, continually supply what has been carried away by the equinoctial currents. This current bears the tropic grape into the high latitudes, toward the coast of Norway and France ; and it is not the Gulf Stream, as some mariners think, which accumulates the fucus to the south of the Azores †. It were to be wished, that navigators heaved the lead more frequently in these latitudes covered with weeds :

\* The *baudreux* of the Falkland islands ; *fucus giganteus*, Forster ; *laminaria pyrifera*, Lamour.

† Barrow, Voyage to Cochinchina, vol. i, p. 93.

for it is asserted, that Dutch pilots have found a series of shoals from the banks of Newfoundland as far as the coasts of Scotland, by using lines composed of silk thread \*.

The causes that unroot these weeds at depths, where it is generally thought the sea is slightly agitated, are not sufficiently known. We learn only, from the luminous observations of Mr. Lamouroux, that if the fucus adhere to the rocks with the greatest firmness before the display of it's fructification, it separates with great facility after this period, or during the season which suspends it's vegetation like that of the terrestrial plants. The fish and the molluscas that gnaw the stems of the seaweeds no doubt contribute also to detach them from their roots.

From the twenty-second degree of latitude, we found the surface of the sea covered with flying fish † which threw themselves up into the air twelve, fifteen, or eighteen feet, and fell down on the deck. I do not hesitate to speak of an object, of which voyagers discourse as frequently as of dolphins, sharks, seasickness, and the phosphorescence of the ocean. None of these objects can fail of affording interesting observations to naturalists, provided they make them their par-

\* Fleurieu. Voy. of the Isis, vol. i, p. 524. (Labillardiere, Voy. vol. i, p. 331.)

† *Exocoetus volitans*.



ticular study. Nature is an inexhaustible source of investigation, and in proportion as the domain of science is extended, she presents herself to those, who know how to interrogate her, under forms which they have never yet examined.

I have named the flying fish in order to fix the attention of naturalists on the enormous size of their natatory bladder, which, in an animal of 6·4 inches, is 3·6 inches long, 0·9 of an inch broad, and contains three cubic inches and a half of air. As this bladder takes up more than half the size of the fish, it is probable that it contributes to it's lightness. We may assert, that this reservoir of air is more fitted for flying than swimming; for the experiments \* made by Mr. Provenzal and myself, have proved, that, even in the species which are provided with this organ, it is not indispensably necessary for the movements of ascension toward the surface of the water. In a young flying fish 5·8 inches long, each of the pectoral fins, which serve as wings, presented a surface to the air of 3·7 square inches. We observed, that the nine branches of nerves, which go to the twelve rays of these fins, are almost three times the size of the nerves that belong to the ventral fins. When the former of these nerves are excited by gal-

\* Researches on the respiration of fishes, and their air-bladder, in the *Mémoires de la Société d'Arcueil*, vol. ii, p. 339.

vanic electricity, the rays which support the membrane of the pectoral fin extend with five times the force with which the other fins move when galvanized by the same metals. By these means the fish is capable of throwing itself horizontally twenty feet distance, before retouching the water with the extremity of it's fins. This motion has been aptly compared to that of a flat stone, which, thrown horizontally, bounds one or two feet above the water. Notwithstanding the extreme rapidity of this motion, it is certain, that the animal beats the air during the leap, that is, it alternately extends and closes it's pectoral fins. The same motion \* has been observed in the flying scorpæna of the rivers of Japan, which contains also a large air-bladder, with which the great part of the scorpænæ, that have not the faculty of flying, are unprovided †. The flying fish, like almost all animals which have gills, enjoy the privilege ‡ of equal respiration for a long time both in water and in air, by the same organs ; that is by extracting the oxygen from the atmosphere as well as from the water in which it is dissolved. They pass a great part of their life in the air, but this life is at best but an unhappy one. If

\* Lacepède, Histoire naturelle des Poissons, vol. iii, p. 290.

† Sporeus, s. scrofa, s dactyloptera. Delaroche, Ann. du Mus. t. 14, p. 189.

‡ Mém. d'Arcueil, t. ii, p. 397.

they escape from the sea to avoid the voracity of the dolphin, they meet in the air men-of-war birds, albatrosses, and other birds, which seize them in their flight. Thus, on the banks of the Oroonoko, herds of river cavies\*, that rush from the water to escape the crocodile, become the prey of the jaguar, which waits their arrival.

I doubt, however, if the flying fish spring out of the water merely to escape the pursuit of their enemies. Like swallows, they move by thousands in a right line, and in a direction constantly opposite to that of the waves. In our own climates, on the brink of a river, the limpid waters of which are illumined by the rays of the sun, we often see solitary fish, with no motive of fear, bound above the surface, as if they felt pleasure in breathing the air. Why should not these gambols be more frequent with the flying-fish, which from the strength of their pectoral fins, and the smallness of their specific gravity†, can so easily support themselves in the air? I invite naturalists to examine whether other flying fish, for instance the *exocoetus exiliens*, the *trigla volitans*, and the *t. hirundo*, have as capacious an air-bladder as the flying fish of the tropics. This last follows the heated waters of

\* *Cavia capybara*, L. † Thick-nosed tapir, Pennant.

† Cuvier, in the *Ann. du Mus.* t. 14, p. 165; and Delaroché, *ibid.* p. 262 (note).

the Gulf Stream when they flow toward the north. The ship boys amuse themselves with cutting off a part of the pectoral fins, and assert, that these wings grow again ; which seems to me not unlikely, from facts observed in other families of fishes.

At the time I left Paris, experiments made at Jamaica, by Dr. Brodbelt \*, on the air contained in the natatory bladder of the sword-fish †, had made some naturalists think, that under the tropics, in the sea fish, this organ was filled with pure oxygen gas. Full of this idea, I was surprised at finding in the air-bladder of the flying fish only 0·04 of oxygen to 0·94 of azot and 0·2 of carbonic acid. The proportion of this last gas, measured by the absorption of lime water in graduated tubes ‡, appeared more constant than that of the oxygen, of which some individuals yielded almost double the quantity. From the curious phenomena observed by Mr. Biot, Configliachi, and Delaroche §, we might suppose, that the sword-fish dissected by Dr. Brodbelt had inhabited the lower strata of the ocean,

\* Duncan's Ann. of Medicine, 1790, p. 393. Nicholson's Journ. of Nat. Phil., 4to. ed., vol. i, p. 264.

† *Xiphias gladius*. Lin.

‡ Anthracometers, curved tubes with a large ball. See my Essays on the atmosphere, plate 1 (German).

§ Mém. d'Arcueil, vol. i, p. 257. Ann. du Mus. t. 14, p. 184—217, and 245—289. Configliachi sull' Analisi dell



where some fish \* have as much as 0.92 of oxygen in their air-bladder.

The 1st of July, in  $17^{\circ} 42'$  latitude and  $34^{\circ} 21'$  longitude, we met with the wreck of a vessel, of which we distinguished the mast covered with floating sea-weed. This shipwreck could not have taken place in a zone where the sea is constantly calm. The wreck came perhaps from the stormy seas of the north, and might be driven back to the point where the vessel had perished, carried on by that extraordinary whirl which the waters of the Atlantic undergo in the northern hemisphere.

On the 3d and 4th, we crossed that part of the ocean, where the charts indicate the bank † of the Maal-stroom; toward night we altered our course to avoid this danger, the existence of which is as doubtful as that of the isles Fon-

Aria contenuta nella Vesica natatoria, Pavia, 1809. Having employed eight months in experiments on the respiration of fishes, Mr. Provenzal and myself observed, that the fishes absorbed not only oxygen, but also azot, and that the quantity of this azot absorbed differs in individuals of the same species. The oxygen inhaled was very far from being equalled by the carbonic acid, which the fish exhale from the whole surface of their body; and these facts tend to prove, that the proportion of oxygen and azot vary in the air-vessel, according as the vital action of the gills and the skin is modified by the greater or less pressure, which the fish undergoes at different depths.

\* *Trigla cucullus*.

† Borda, Voyage de la Flore, vol. ii, p. 314.



seco and St. Anne\*. It would have been perhaps as prudent to have continued our course. The old charts are filled with rocks, some of which really exist, but the greater part are owing to those optical illusions, which are more frequent at sea than in inland countries. The position of the real dangers is generally indicated by chance; they have been seen by pilots who were several degrees out in their longitude, and we might be certain of meeting neither with rocks nor breakers, if we directed our course toward the points where they are laid down on the maps. As we approached this pretended Maal-stroom, we observed no other motion in the

\* Jeffery's and Van-Keulen's charts indicate four islands, which are only imaginary dangers: the islands Garca and St. Anne, to the west of the Azores; the Green island (latitude  $44^{\circ} 52'$ , longitude  $28^{\circ} 30'$ ) and the isle of Fonseca (latitude  $13^{\circ} 15'$ , longitude  $57^{\circ} 10'$ ). How is it possible to believe in the existence of four islands in latitudes crossed by thousands of vessels, when of so many small rocks and shoals, announced by credulous pilots for a century past, there are scarcely above two or three that are real? As to the general question, what is the degree of probability we may admit, that an islet visible at the distance of a league may be discovered between America and Europe, we might submit this to a rigorous calculation, if we knew the number of ships that have annually crossed the Atlantic these three centuries past, and if regard be had to the unequal distribution of those vessels in different latitudes. If the Maal-stroom were, as Van Keulen admits, in  $16^{\circ}$  of latitude and  $39^{\circ} 30'$  of longitude, we should have crossed it the 4th of June.

waters than the effect of a current which bore to the north-west, and which hindered us from diminishing our latitude as much as we wished. The force of this current augments as we approach the new continent; it is modified by the configuration of the coasts of Brazil and Guiana, and not by the waters of the Oroonoko and the Amazons, as some naturalists pretend.

From the time we entered the torrid zone, we were never wearied with admiring, every night, the beauty of the southern sky, which, as we advanced toward the south, opened new constellations to our view. We feel an indescribable sensation, when, on approaching the equator, and particularly on passing from one hemisphere to the other, we see those stars, which we have contemplated from our infancy, progressively sink, and finally disappear. Nothing awakens in the traveller a livelier remembrance of the immense distance by which he is separated from his country, than the aspect of an unknown firmament. The grouping of the stars of the first magnitude, some scattered nebulæ, rivaling in splendor the milky way, and tracks of space remarkable for their extreme blackness, give a particular physiognomy to the southern sky. This sight fills with admiration even those, who, uninstructed in the branches of accurate science, feel the same emotion of delight in the contemplation of the heavenly vault, as in the

view of a beautiful landscape, or a majestic site. A traveller has no need of being a botanist, to recognize the torrid zone on the mere aspect of it's vegetation ; and without having acquired any notions of astronomy, without any acquaintance with the celestial charts of Flamstead and de la Caille, he feels he is not in Europe, when he sees the immense constellation of the Ship, or the phosphorescent clouds of Magellan, arise on the horizon. The heaven, and the earth, every thing in the equinoctial regions, assumes an exotic character.

The lower regions of the air were loaded with vapors for some days. We saw distinctly for the first time the Cross of the South only in the night of the 4th and 5th of July, in the sixteenth degree of latitude ; it was strongly inclined, and appeared from time to time between the clouds, the centre of which, furrowed by uncondensed lightnings, reflected a silver light. If a traveller may be permitted to speak of his personal emotions, I shall add, that in this night I saw one of the reveries of my earliest youth accomplished.

When we begin to fix our eyes on geographical maps, and read the narratives of navigators, we feel for certain countries and climates a sort of predilection, for which we know not how to account at a more advanced period of life. These impressions, however, exercise a considerable influence over our determinations ; and from a

sort of instinct we endeavour to connect ourselves with objects, on which the mind has long been fixed as by a secret charm. At a period when I studied the heavens, not with the intention of devoting myself to astronomy, but only to acquire a knowledge of the stars, I was agitated by a fear unknown to those who love a sedentary life. It seemed painful to me to renounce the hope of beholding those beautiful constellations, which border the southern pole. Impatient to rove in the equinoctial regions, I could not raise my eyes toward the starry vault without thinking of the Cross of the South, and without recalling the sublime passage of Dante, which the most celebrated commentators have applied to this constellation ;

*Io mi volsi a man destra e posi mente.  
All' altro polo e vidi quattro stelle  
Non viste mai fuor ch' alla prima gente.*

*Goder parca lo ciel di lor fiammelle ;  
O settentrional vedovo sito  
Poi che privato se' di mirar quelle !*

The pleasure we felt on discovering the southern Cross was warmly shared by such of the crew as had lived in the colonies. In the solitude of the seas, we hail a star as a friend, from whom we have long been separated. Among the Portuguese and the Spaniards peculiar motives seem to increase this feeling ; a religious



sentiment attaches them to a constellation, the form of which recalls the sign of the faith planted by their ancestors in the deserts of the new world.

The two great stars which mark the summit and the foot of the Cross having nearly the same right ascension, it follows hence, that the constellation is almost perpendicular at the moment when it passes the meridian. This circumstance is known to every nation, that lives beyond the tropics, or in the southern hemisphere. It has been observed at what hour of the night, in different seasons, the Cross of the South is erect, or inclined. It is a time-piece that advances very regularly near four minutes a day, and no other group of stars exhibits, to the naked eye, an observation of time so easily made. How often have we heard our guides exclaim in the savannahs of the Venezuela, or in the desert extending from Lima to Truxillo, "Midnight is past, the Cross begins to bend!" How often those words reminded us of that affecting scene, where Paul and Virginia, seated near the source of the river of Lataniers, conversed together for the last time, and where the old man, at the sight of the southern Cross, warns them that it is time to separate.

The last days of our passage were not so happy, as the mildness of the climate, and the calmness of the ocean, had led us to hope. The dan-



gers of the sea did not disturb our enjoyments, but the germe of a malignant fever discovered itself as we drew near the antilles. Between decks the ship was excessively hot, and very much encumbered. From the time we passed the tropic, the thermometer was at thirty-four or thirty-six degrees. Two sailors, several passengers, and, what is remarkable enough, two negroes from the coast of Guinea, and a mulatto child, were attacked with a disorder which appeared epidemic. The symptoms were not equally alarming in them all; nevertheless, several persons, and especially the most robust, fell into a delirium after the second day, and felt a total prostration of their strength. The indifference which prevails on board packet boats, for every thing that does not regard the working of the ship, and the quickness of the passage, prevented the captain from employing the ordinary means of diminishing the danger which threatened us. No fumigation was made. A Gallician surgeon, ignorant and phlegmatic, ordered bleedings, because he attributed the fever to what he called heat and corruption of the blood. There was not an ounce of bark on board; we had forgot to take any with us, because, being more occupied with our instruments than our health, we thought too carelessly, that this salutary production of Peru could not fail to be found on board a Spanish vessel.

The 8th of July, a sailor, who was near expiring, recovered his health from a circumstance that is worthy of being mentioned. His hammock was so hung, that there was not ten inches between his face and the deck. It was impossible to administer the sacraments in this situation; for, agreeably to the custom aboard Spanish vessels, the viaticum ought to be carried by the light of tapers, and followed by the whole crew. The patient was removed into an airy place, near the hatchway, where a small square birth had been formed with sail cloth. Here he was to remain till he died, which was an event expected every moment; but passing from an air extremely heated, stagnant, and filled with miasms, into fresher and purer air, which was renewed every instant, he gradually revived from his lethargic state. His recovery dated from the day when he quitted the middle deck; and as often in medicine the same facts are cited in support of systems diametrically opposite; this recovery confirmed our doctor in his ideas of the inflammation of the blood, and the necessity of bleeding, evacuating, and all the asthenic remedies. We soon felt the fatal effects of this treatment; and wished more than ever to reach the coasts of America.

For several days the pilot's reckoning differed  $1^{\circ} 12'$  in longitude from that of my time-keeper. This difference was owing less to the general cur-

rent, which I have called the *current of rotation*, than to that particular movement, which drawing the waters toward the north-west, from the coast of Brazil to the Antilles, shortens the passage from Cayenne to Guadaloupe\*. The 12th of July, I thought I might foretell our seeing land the next day before sunrise. We found ourselves then, according to my observations, in latitude  $10^{\circ} 46'$ , and west longitude  $60^{\circ} 54'$ . A few series of lunar distances confirmed the chronometrical result; but we were surer of the position of the vessel, than of that of the land to which we directed our course, and which was so differently placed in the French, Spanish, and English charts. The longitudes, deduced from the accurate observations of Messrs. Churruca, Fidalgo, and Noguera, were not published at this period.

The pilots trusted more to the log than the time-keeper; they smiled at the prediction of speedily making the land, and thought themselves two or three days sail from the coast. It was therefore with great pleasure, that on the 13th, toward six in the morning, I learnt that

\* In the Atlantic Ocean there is a space, where the water is constantly milky, though the sea is very deep. This curious phenomenon exists in the parallel of the island of Dominica, very near the 57th degree of longitude. May there not be in this place some sunk volcanic islet, more easterly still than Barbadoes?

very high land was seen from the mast-head, though not clearly, as it was surrounded with a thick fog. The wind blew hard, and the sea was very rough. Large drops of rain fell at intervals, and every appearance menaced tempestuous weather. The captain of the Pizarro intended to pass through the channel, which separates the isle of Tobago from that of Trinidad; and knowing that our sloop was very slow in tacking, he was afraid of falling to leeward toward the south, and approaching the Bocca-del-Drago. We were in fact surer of our longitude than of our latitude, having had no observation at noon since the 11th. Double altitudes which I took in the morning, after Douwes's method, placed us in  $11^{\circ} 6' 50''$ , consequently  $15'$  north of our reckoning. The impetuosity, with which the great river Oroonoko throws it's waters into the ocean, may undoubtedly, in these latitudes, increase the strength of the currents; but what has been stated respecting the change of color and the saltness of the water, at sixty leagues from the mouth of the Oroonoko, is a fable invented by the coasting pilots. The influence of the most considerable rivers of America, such as the Amazons, the Plata, the Oroonoko, the Mississippi, and the Magdalena, is restricted, in this respect, within much narrower limits than is generally thought.

Although the result of the double altitudes of

the sun proved clearly, that the high land in the horizon was not Trinidad, but Tobago, the captain continued to steer N. N. W., in search of this latter island, which, even in Borda's chart, is placed 5' too far south. We can scarcely believe, that on coasts frequented by every trading nation, such enormous errors in latitude should be thus perpetuated for ages. Having discussed this matter in another place \*, it is sufficient here to observe, that even in the last chart of the West Indies, published by Mr. Arrowsmith, in 1803, consequently a long time after the labours of Churruca, the latitudes of the different capes of Tobago and Trinidad, are still from six to eleven minutes erroneous.

An observation of the meridian altitude of the Sun fully confirmed the latitude obtained by Douwes's method. No more doubt remained respecting the position of the vessel, with respect to the island, and we resolved to double Cape North in Tobago, to pass between this island and Grenada, and steer toward a port in Margarettta. In these latitudes we ran at every moment the risk of being taken by privateers ; but happily for us the sea was very rough, and a small English cutter passed without hailing us. As to Mr. Bonpland and myself, we were less afraid of this, since, as we were so near the continent

\* Obs. Ast. p. 35 to 39, and Introduction, p. 38. (Chart of the Atlantic Ocean. Sixth edition.)



of America, we were sure of not being carried back to Europe.

The island of Tobago presents itself under a very picturesque aspect. It is a heap of rocks carefully cultivated. The dazzling whiteness of the stone forms an agreeable contrast with the verdure of some scattered tufts of trees. Cy-lindric and very lofty opuntia crown the top of the mountains, and give a peculiar physiognomy to this tropical landscape. Their sight alone is sufficient to remind the navigator, that he has arrived at an American coast; for cactuses are exclusively peculiar to the New World, as heaths to the Old\*. The north-west part of the island of Tobago is the least mountainous; according to the angles of height, taken with the sextant, the most lofty points of the coast do not appear to exceed 140 or 150 toises. At South-west Cape, the land descends toward Sandy Point, the latitude of which I found to be  $10^{\circ} 20' 13''$ , and the longitude  $62^{\circ} 47' 30''$ . We perceived several rocks on a level with the water, on which the sea broke violently, and we distinguished a great regularity in the inclination and direction of the strata, which dip to the south-west at an angle of  $60^{\circ}$ . It were to be wished, that the tour of the West Indies, from the coast of Paria to Cape Florida, were made by a good mineral-

\* Essay on the Physiognomy of Plants. See my Views of Nature, vol. i, p. 47.

ogist, who would examine this ancient chain of mountains broken by the action of currents, earthquakes, and volcanoes.

After having doubled the north cape of Tobago, and the small island of St. Giles, we were alarmed with the news of an enemy's squadron seen from the mast-head ; the passengers were in the utmost consternation, for several had laid out their small fortunes in goods, which they counted on selling in the Spanish colonies. The squadron seemed motionless, and we soon discovered, that what we had taken for ships was a multitude of separate rocks \*.

We crossed the shoal which joins Tobago to the island of Grenada. The color of the sea had no visible change : but the centigrade thermometer, plunged into the water at some inches depth, rose only to  $23^{\circ}$  ; while farther at sea eastward on the same parallel, and equally near the surface, it kept at  $25.6^{\circ}$ . Notwithstanding the currents, the cooling of the water indicated the existence of the shoal, which is noted but in a small number of charts. The wind slackened after sunset, and the clouds disappeared as the moon reached the zenith. The number of falling stars was very considerable both this and the following nights ; they appeared less frequent toward the north than the south over Terra

\* Perhaps the rocks called the *Hermanas* (the Sisters).

Firma, which we began to coast. This position seems to prove the influence of local causes on meteors, the nature of which is not yet sufficiently known to us.

The 14th at sunrise, we were in sight of the Bocca-del-Drago. We distinguished the island Chacachacarreo, the most westerly of those islands which are placed between Cape Paria and the north-west cape of Trinidad. When we were five leagues distant from the coast, we felt, near *Punta de la Baca*, the effect of a particular current, which drew the ship toward the south. The motion of the waters which flow through the Bocca-del-Drago, and the action of the tides, occasion an eddy. We hove the lead, and found from thirty-six to forty-three fathoms on a bottom of very fine green clay. According to the rules established by Dampier\*, we ought not to have expected so little depth near a coast formed by very high and perpendicular mountains. We continued to heave the lead till we reached *Cabo de tres Puntas*, and we every where found shallow water, apparently indicating the prolongation of the ancient coast. In these latitudes the temperature of the sea was twenty-three or twenty-four degrees, consequently from 1.5 to two degrees less than in the open ocean, beyond the edges of the bank.

Cape Three Points, the name given to it by

\* Voyage round the World, vol. ii, p. 476.

Columbus himself \*, is, according to my observations, in  $65^{\circ} 4' 5''$  longitude. It seemed to us so much the more elevated, as the clouds concealed from us the view of it's indented top. The physiognomy of the mountains of Paria, their color, and especially their generally rounded forms, made us suspect, that the coast was granitic; but we afterwards recognized how delusive, even for those who have passed their lives in scaling mountains, are opinions respecting the nature of rocks seen at a distance.

A dead calm, which lasted several hours, permitted us to determine with exactness the intensity of the magnetic forces opposite the *Cabo de tres Puntas*. This intensity was greater than in the open sea, to the east of the island of Tobago, in the ratio of 237 to 229. During the calm the current drew us on rapidly to the west. It's velocity was three miles an hour, and increased as we approached the meridian of *Testigos*, a heap of rocks which rise up amidst the waters. At the setting of the Moon, the sky was covered with clouds, the wind freshened anew, and the rain descended in one of those torrents, which are peculiar to the torrid zone, and to which we were often exposed during our inland excursions.

The malady which had broke out on board the Pizarro had made rapid progress, from the

\* Month of August, 1598.



time we came on the coasts : the thermometer kept regularly during the night between twenty-two and twenty-three degrees, and during the day from twenty-four to twenty-seven. The congestions toward the head, excessive dryness of the skin, extreme weakness, all the symptoms grew more alarming ; but having almost reached the end of our voyage, we flattered ourselves, that all who were sick would be restored to health, as soon as we could land them at the isle of St. Margareta, or the port of Cumana, distinguished for their great salubrity.

This hope was not altogether realized. The youngest of the passengers attacked with the malignant fever was happily the first and only victim. He was an Asturian, nineteen years of age, the only son of a poor widow. Several circumstances rendered the death of this young man affecting. His features bore the marks of sensibility, and a great mildness of disposition ; he had embarked against his inclination, and his mother, whom he had hoped to assist by the produce of his labors, had sacrificed her own tenderness to the idea of securing the fortune of her son, by sending him to the colonies to a rich relation, who resided at the isle of Cuba. The unfortunate young man expired the third day of his illness, having fallen from the beginning into a lethargic state interrupted by fits of delirium. The yellow fever, or black vomiting, at Vera



Cruz, scarcely carries off the sick with so alarming a rapidity. Another Asturian, still younger, did not leave one moment the bed of his dying friend, and, what is very remarkable, did not contract the disorder. He was to follow his countryman to St. Jago de Cuba, by whom he was to be introduced to the house of this relation, on whom all their hopes depended. Nothing could be more affecting than the sorrow of him who had survived his friend, and who bewailed with bitterness the fatal counsels, which had thrown him on a foreign climate, where he found himself abandoned, and without support.

We were assembled on the deck, absorbed in melancholy reflections. It was no longer doubtful, that the fever which raged on board had assumed in these last days a fatal aspect. Our eyes were fixed on a hilly and desert coast, on which the Moon, from time to time, shed its light athwart the clouds. The sea, gently agitated, shone with a feeble phosphoric glittering. Nothing was heard but the monotonous cry of a few large sea-birds, flying toward the shore. A profound calm reigned over these solitary abodes, but this calm of nature was in discordance with the painful feelings by which we were oppressed. About eight the dead man's knell was slowly tolled ; at this lugubrious sound, the sailors ceased their labor, and threw themselves

on their knees to offer a momentary prayer ; an affecting ceremony, which, while it brought to our remembrance those times, when the primitive Christians considered themselves as members of the same family, seemed to blend mankind into one common feeling from the sentiment of a common evil. The corpse of the Asturian was brought upon deck during the night, and the priest entreated, that it might not be committed to the waves till after sunrise, in order to pay it the last rites, according to the usage of the Romish church. There was not an individual on board, who did not sympathise with the fate of this young man, whom we had beheld, but a few days before, full of cheerfulness and health.

The event I have just related proved the danger of this malignant fever\*, the victims of which, we apprehended, might be very numerous, if a continuance of calms should lengthen the passage from Cumana to the Havannah. On board a ship of war, or a transport, the death of a few individuals commonly makes no more impression, than the sight of a funeral procession in a populous city : not so on board a packet, the crew of which are few in number, and where the persons who have the same end in view form habits of intimacy with each other. The passengers of the Pizarro, who had not yet felt the symptoms of the disease, resolved to leave the vessel at the first place

\* *Typhus*, Sauvages ; *Febris nervosa*, Frank.

where she touched, and wait the arrival of another packet, to pursue their course to the island of Cuba and to Mexico. They considered the between decks of the ship as pestiferous ; and though it was by no means clear to me, that the fever was contagious from contact \*, I thought it most prudent to land at Cumana. I wished not to visit New Spain till I had made some abode on the coasts of Venezuela and Paria ; a small number of the productions of which had been examined by the unfortunate Loeffling. We were anxious to behold in their native site the beautiful plants, which Bose and Bredemeyer had collected during their journey to the continent, and which adorn the green-houses of Schoenbrunn and Vienna. It would have been painful to have touched at Cumana, or at Guayra, without visiting the interior of a country so little frequented by naturalists.

The resolution we took during the night of the 14th and 15th of July had a happy influence on the direction of our travels. Instead of a few weeks, we remained a whole year in this part of the continent ; had not the fever raged on board the Pizarro, we should never have reached the

\* The sailor of whom I have just spoken, and who escaped death by the change of air, was but slightly indisposed when he came on board at Corunna ; it was no doubt from some peculiar disposition of his organs, that he was first attacked with the malignant fever, when we entered the torrid zone.

Oroonoko, the Cassiquiare, and even the limits of the Portuguese possessions on the Rio Negro. We were also indebted perhaps to this direction \*given to our travels for the state of health we enjoyed during so long an abode in the equinoctial regions.

It is well known, that Europeans, during the first months after their arrival under the scorching sky of the tropics, are exposed to the greatest dangers. They consider themselves as seasoned, when they have passed the rainy season in the West India islands, at Vera Cruz, or at Carthagena. This opinion is very general, although there are examples of persons, who, having escaped a first attack of the yellow fever, have perished victims of the same disease in one of the following years. The facility of being seasoned seems to be in the inverse ratio of the difference that exists between the mean temperature of the torrid zone, and that of the country in which the traveller, or planter, who changes his climate, is born; because the irritability of the organs, and their vital action, are powerfully modified by the influence of the atmospheric heat. A Prussian, a Polander, or a Swede, is more exposed on their arrival at the islands or on the continent, than a Spaniard, an Italian, or even an inhabitant of the South of France \*. With respect to the people of the north, the

\* New Spain, vol. ii, p. 754.



difference of the mean temperature is from nineteen to twenty-one degrees, while to the people of southern countries it is only from nine to ten. We were fortunate enough to pass the time, when a European recently landed runs the greatest danger, in the extremely hot, but very dry climate of Cumana, a city celebrated for it's salubrity. Had we continued our voyage to Vera Cruz, we should perhaps have shared in the unhappy fate of several passengers of the packet boat, the Alcudia, which arrived at the Havannah with the Pizarro, at a period when the black vomiting made such cruel ravages in the island of Cuba, and on the eastern coasts of Mexico.

The 15th, in the morning, when nearly abreast of the hill of St. Joseph, we were surrounded by a great quantity of floating sea weed. It's stems had those extraordinary appendages in the form of little cups and feathers, which Don Hippolyto Ruiz remarked on his return from the expedition to Chili, and which he described in a separate memoir as the sexual organs of the fucus natans. A fortunate accident allowed us the means of verifying a fact, which had been but once observed by naturalists. The bundles of fucus collected by Mr. Bonpland were completely identical with the specimens given us by the learned authors of the Flora of Peru. On examining both with the microscope, we found, that these pretended parts of fructification, these



stamina and pistils, belong to a new genus of the family of the ceratophytæ. The small cups, which Mr. Ruiz took for pistils, proceed from horny and flattened stems, which are so intimately united to the substance of the fucus, that we might be tempted to take them for mere fasciculated fibres; but these horny stems may be separated by a very thin blade, without hurting the parenchyma. They are unarticulated, and at first of a dark brown; but they become in time, by drying, white and friable; in this state they effervesce with acids, as the calcareous substance of the sertularia, the extremities of which very much resemble the cups of the fucus of Mr. Ruiz. We found again, in the South Sea, on our voyage from Guayaquil to Acapulco, these same appendages to the tropic grape, and the most attentive examination left us no doubt, that a zoophyte is attached to the fucus, as ivy entwines the trunks of trees. The organs described under the name of female flowers are more than two lines along, and their size alone should have removed the suspicion, that these parts were real pistils.

The coast of Paria stretches to the west, forming a wall of rocks of no great height, with rounded tops and a waving outline. We were long without perceiving the bold coasts of the island of Margarettæ, where we were to stop in order to obtain information respecting the Eng-

lish cruizers, and the danger of touching at Guayra. We had learnt by altitudes of the sun, taken under very favorable circumstances, how incorrect at this period were the most esteemed marine charts. On the fifteenth in the morning, when the time keeper placed us in  $66^{\circ} 1' 15''$  longitude, we were not yet in the meridian of Margaretta island; though according to the reduced chart of the Atlantic ocean \* we ought to have passed the very lofty western cape of this island, which is laid down in longitude  $66^{\circ}$ . The inaccuracy with which the coasts were delineated previous to the works of Messrs. Fidalgo, Noguera, and Tiscar †, and I may ven-

\* Constructed at the *Depôt de la Marine* in 1786, and corrected in 1792.

† *Carta general del oceano Atlantico construida en el Depósito hydrographico de Madrid en el anno 1800, et corregida en 1804. Carta esferica de las Islas Antillas con parte de la costa del continente de America, trabajada por don Cosme Churruca y Don Joaquin Francisco Fidalgo, 1802.* These two charts have served as bases to all those that have appeared in these latter times in different parts of Europe, which, copied one from another, differ only in numberless calcographical errors. Most of the original observations of the Spanish astronomers are mentioned in Mr. Espinosa's valuable work, entitled, *Memorias sobre las Observaciones astronomicas hechas por los Navegantes Espannoles en distintos Lugares del Globo* (2 vols. 4to, Madrid, 1809). I have compared, step by step, the results of these observations with those on which Mr. Oltmann and myself are agreed (*Astron. Obs.* vol. i; *Introd.* p. 33—49). This comparison will be useful to those, who may hereafter

ture to add, before the astronomical observations I made at Cumana, might have become dangerous to navigators, were not the sea uniformly calm in those regions. The errors in latitude were still greater than those in longitude, since the coasts of New Andalusia stretch to the westward of Cape Three Points fifteen or twenty miles more to the north, than appears in the charts published before the year 1800.

Toward eleven in the morning, we perceived a very low islet, covered with a few sandy downs; and on which we discovered with our glasses no trace of habitation or culture. Cylindrical cactuses rose here and there in the form of candelabra. The soil, almost destitute of vegetation, seemed to have a waving motion, in consequence of the extraordinary refraction, which the rays of the sun undergo in traversing the strata of air in contact with plains strongly heated. Under every zone, deserts and sandy shores appear like an agitated sea, from the effect of looming.

The appearance of so flat a country scarcely corresponded with the ideas we had formed of the island of Margareta. While we were busy in laying down our bearings on the charts, and

publish charts of America; the new determinations deserving so much the more confidence, as the positions have been verified by very different astronomical methods, and by observers who did not communicate their results to each other, till long after they had terminated their labours,

unable to make them correspond, a few small fishing boats were descried from the mast-head. The captain of the Pizarro fired a gun for them ; but this signal was useless on a coast where the weak apprehended that they meet with the strong only to be insulted. The boats hastened away toward the west, and we found ourselves in the same perplexity as we had been with respect to the small island of Graciosa, on our arrival at the Canaries. No person on board had landed on this spot, or could give us any information respecting it. Though the sea was very calm, the proximity of an islet, which rose scarcely a few feet above the surface of the water, seemed to prescribe measures of prudence. We ceased to stand toward the land ; and as the lead gave but three or four fathoms, we speedily let go an anchor.

The coasts, seen at a distance, are like clouds, in which each observer meets the form of the objects that occupy his imagination. Our bearings and our chronometer being at variance with the charts which we had to consult, we were lost in vain conjectures. Some took mounds of sand for Indian huts, and pointed out the place, where, according to them, the fort of Pampatar was situate ; others saw herds of goats, which are so common in the dry valley of St. John ; or descried the lofty mountains of Macanao, which seemed to them partly hidden by the clouds.

The captain resolved to send a pilot on shore, and the men were preparing to hoist out the long-boat, the cutter having been damaged by the surge in the road of Santa Cruz ; but the coast being still far off, the return of the boat might have become difficult, if the breeze had freshened toward evening.

At the moment we were preparing to go on shore, we perceived two canoes sailing along the coast. Again we fired a gun as a signal for these; and though we had hoisted Spanish colours, they drew near with distrust. These canoes, like all those made use of by the natives, were constructed of the single trunk of a tree; and in each were eighteen Guayqueria Indians, naked to the waist, of very tall stature. They had the appearance of great muscular strength, and the color of their skin was something between a brown and a copper color. Seen at a distance, motionless in their attitudes, and projected on the horizon, they might have been taken for statues of bronze. We were so much the more struck with this aspect, as it did not correspond with the ideas we had formed from the accounts of travellers of the characteristic features and extreme weakness of the natives. We afterward learnt without passing the limits of the province of Cumana, the great contrast that exists between the physiognomy of the Guayquerias and that of the Chaymas and the



Caribs. Notwithstanding the intimate ties, which appear to unite the whole of the American nations as belonging to the same race, several tribes do not the less differ from each other in the height of their stature, their complexion more or less tawny, and their looks, which in some express tranquillity and mildness, in others a sinister mixture of melancholy and ferocity.

When we were near enough to hail them in Spanish, the Indians threw aside their mistrust, and came straight on board. They informed us, that the low islet near which we were at anchor was that of Coche, which had never been inhabited ; and that the Spanish vessels coming from Europe were accustomed to sail farther north, between this island and that of Margareta, to take a coasting pilot at the port of Pampatar. Our inexperience had led us into the channel to the south of Coche; and as at this period the English cruisers frequented this passage, the Indians had taken us for an enemy's ship. The southern passage is in fact highly advantageous for vessels going to Cumana and Barcelona: it has less water than the northern passage, which is much narrower: but there is no risk of touching the ground, if vessels keep very close to the island of Lobos and the Moros del Tunal. The channel between Coche and Margareta is narrowed by the shoals off the north-west cape of Coche, and by the bank that surrounds la Punta de

Mangles. We shall examine in another place, under a geological point of view, this bank of sand, which surrounds the rocks of Testigos and Margareta; and shall show, that the latter island was formerly united, by means of Coche and Lobos, to the Peninsula of Chacopapa.

The Guayquerias belong to that tribe of civilized Indians, who inhabit the coasts of Margareta, and the suburbs of the city of Cumana. Next to the Caribs of Spanish Guyana, it is the finest race of men in Terra Firma. They enjoy several privileges, because from the earliest times of the conquest they remained faithful friends to the Castilians. The king of Spain names them in his public acts, "his dear, noble, and loyal Guayquerias." The Indians of the two canoes we had met had left the port of Cumana during the night. They were going in search of timber to the cedar \* forests, which extend from Cape San Jose farther than the mouth of Rio Carupano. They gave us some fresh cocoa nuts, and very beautifully colored fish of the *chaetodon* genus†. What riches to our eyes were contained in the canoes of these poor Indians! Broad spreading leaves of vijao ‡ covered bunches of plantains. The scaly cuirass

\* *Cedrela odorata*, Lin.

† *Bandonnières*.

‡ *Heliconia bihai*.

of an armadillo \*, the fruit of the calabash tree, *crescentia cujete*, used as a cup by the natives, the productions most common in the cabinets of Europe, had a peculiar charm for us, because they reminded us, that, having reached the torrid zone, we had attained the end toward which our wishes had been so long directed.

The master of one of the canoes offered to remain on board the Pizarro as coasting pilot†. He was a Guayqueria of an excellent disposition, sagacious in his observations, and led by an unceasing curiosity to notice the productions of the sea, as well as the plants of the country. By a fortunate chance, the first Indian we met on our arrival was the man, whose acquaintance became the most useful to us in the course of our researches. I feel a pleasure in recording in this itinerary the name of Carlos del Pino, who, during the space of sixteen months, attended us in our course along the coasts, and into the inland country.

The captain of the corvette weighed anchor toward the evening. Before we left the shoal or *placer* of Coche, I ascertained the longitude of the east cape of the island, which I found to be  $66^{\circ} 11' 53''$ . As we steered toward the west, we soon came in sight of the little island of Cubagua, now entirely deserted, but formerly celebrated

\* *Dasypus*, *cachicamo*.

† Practico.

for it's fishery of pearls. There the Spaniards, immediately after the voyages of Columbus and Ojeda, founded, under the name of New Cadiz, a town, of which there now remains no vestige. At the beginning of the sixteenth century, the pearls of Cubagua were known at Seville, at Toledo, and at the great fairs of Augsburg and Bruges. New Cadiz having no water, that of the Rio Manzanares was conveyed thither from the neighbouring coast, though for some reason, I know not what, it was thought to be the cause of diseases of the eyes\*. The writers of that period all speak of the riches of the first planters, and the luxury they displayed; at present, downs of shifting sand cover this uninhabited land, and the name of Cubagua is scarcely found in our charts.

Having reached these latitudes, we saw the high mountains of Cape Macanao, on the western side of the isle of Margaretta, which rose majestically on the horizon. If we might judge from the angles of altitude of the tops, taken at eighteen miles distance, they appeared to be about 5 or 600 toises high. According to Berthoud's time-keeper, the longitude of Cape Macanao is  $66^{\circ} 47' 5''$ . I speak of the rocks at the extremity of this cape, and not that strip of very low land, which stretches toward the west, and

\* Herrera, *Descrip. de las Indias occidentales* (Madrid, 1730), vol. i, p. 12.



loses itself in a shoal. The position of Macanao, and that which I have assigned to the east point of the island of Coche, differ only four seconds in time from the results obtained by Mr. Fidalgo.

There being little wind, the captain preferred standing off and on till day break. He was afraid to enter the port of Cumana during the night; and this prudence seemed necessary, on account of an unfortunate accident, which had lately taken place on this coast. A packet that had anchored during the night, without lighting her poop-lanterns, was taken for an enemy's ship, and was fired on from the batteries of Cumana. The captain of the packet had his leg shot off, and died a few days after at that port.

We passed a part of the night on deck. The Guayqueria pilot conversed with us on the animals and plants of his country. We learnt with great satisfaction, that a few leagues from the coast was a mountainous region inhabited by the Spaniards, in which the cold was very much felt; and that in the plains there were two species of crocodiles, very different from each other\*, boas, electric eels†, and several kinds of tigers. Though the words *bava*, *cachicamo*, and *temblador*, were entirely unknown to us, we easily guessed, from his simple description of their

\* *Crocodilus acutus*, and *c. bava*.

† *Gymnotus electricus*, *temblador*.



manners and forms, the species which the creoles meant by these denominations. Forgetting that these animals are dispersed over a vast extent of country, we hoped to find them in the forests of Cumana. Nothing so much excites the curiosity of a naturalist, as the recital of the wonders of a country where he is on the point of landing.

On the 16th of July, 1799, at the point of day, we saw a verdant coast, of picturesque aspect. The mountains of New Andalusia, half veiled by mists, bounded the horizon to the south. The city of Cumana and its castle appeared between groups of cocoa trees. We anchored in the port about nine in the morning, forty-one days after our departure from Corunna. The sick dragged themselves on deck to enjoy the sight of a land, which was about to put an end to their sufferings.

I was unwilling to interrupt the narrative of our voyage by the detail of the physical observations I made during the passage from the coasts of Spain to Teneriffe, and thence to Cumana. Observations of this kind are not really interesting, except when we can dispose their results in such a manner as to lead to general ideas. The form of a personal narrative, and the nature of its composition, are not well fitted for the full explanation of phenomena, which vary with the seasons, and the position of places. In order to

study the laws of these phenomena, we must exhibit them in groups, and not separately, as they were successively observed. We are under great obligations to navigators, who have accumulated an immense number of facts; but must regret, that hitherto naturalists have made so little use of their journals, which, when examined anew, may yield unexpected results. I shall insert at the end of this chapter the experiments, which I made on the temperature of the atmosphere and the ocean, with the hygrometrical state of the air, the intensity of the blue color of the sky, and the magnetic phenomena.

#### TEMPERATURE OF THE AIR.

In the vast basin of the Northern Atlantic Ocean, between the coasts of Europe, Africa, and the New Continent, the temperature of the atmosphere offered us a very slow increment, as we passed from the 43d to the 10th degree of latitude. From Corunna to the Canary islands, the centigrade thermometer, observed at noon and in the shade, ascended gradually from ten to eighteen degrees\*; from Santa Cruz in Teneriffe to Cumana, the same instrument rose from eighteen to twenty-five degrees†. In the

\* From the 6th to the 19th of June. See the particular observations in the journal at the end of this chapter.

† From the 25th of June to the 15th of July.

first part of the voyage, a difference of a degree of temperature corresponded to  $1^{\circ} 48'$  of latitude; in the second part, we must traverse  $2^{\circ} 30'$  of latitude to see the thermometer rise one degree. The maximum of the heat, which the air gradually attains two hours after the passage of the sun over the meridian, did not exceed, during this voyage,  $26^{\circ} 6'$  ( $21.3^{\circ}$  Reaumur); nevertheless we were in the month of July, and ten degrees to the south of the tropic of Cancer. The evaporation of the water, augmented by the motion of the air and of the waves, and the property which transparent liquids have\* of absorbing very little light at their surface, contribute equally to moderate the heat in the part of the atmosphere that surrounds the equinoctial seas. It is well known, that as long as the breeze blows under the torrid zone, navigators are never exposed to violent heats.

If we compare† the numerous observations made in the South Sea and the Atlantic Ocean during the voyages of Cook, Dixon, d'Entrecasteaux, and Krusenstern, we find, that, between the tropics, the mean temperature of the air at

\* The rays of light penetrate the water to considerable depths; and the first strata, by freely transmitting them, are not heated like the earth and rocks.

† See an excellent memoir by Messrs. Horner and Langsdorf in the memoirs of the Academy of Petersburg, vol. i, p. 467.

sea is from twenty-six to twenty-seven degrees. We must exclude from this statement the observations made during a dead calm, because the body of the vessel is then extraordinarily heated, and it is almost impossible to make a just estimation of the temperature of the atmosphere. When we look into the journals of so many celebrated navigators, we are surprised to see, that never, in either hemisphere, have they observed the thermometer under the torrid zone, in the open sea, above  $34^{\circ}$  ( $27\cdot2^{\circ}$  R). In thousands of observations made at the time of the passage of the Sun across the meridian, we scarcely find a few days when the heat has risen to thirty-one or thirty-two degrees ( $24\cdot8^{\circ}$  or  $25\cdot6^{\circ}$  R.); while on the continents of Africa and Asia, under the same parallels, the temperature often exceeds thirty-five or thirty-six degrees. In general, between ten degrees of north and ten of south latitude, the mean heat of the atmosphere that rests on the ocean appears to me, in the low regions, from one to two degrees lower than the mean temperature of the air that surrounds the land situate between the two tropics. It is useless in this place to observe how much this circumstance modifies the climate of the whole Globe, on account of the unequal distribution of the continents at the north and south of the equator, as well as to the east and west of the meridian of Teneriffe.



The extreme slowness, with which the temperature increases during the passage from Spain to the New Continent, is highly advantageous to the health of Europeans, who go to settle in the colonies. At Vera Cruz and at Carthagena, the creoles who descend from the high savannahs of Bogota, and the central elevated plain of New Spain, are more exposed on the coasts to the attack of the yellow fever, or *vomito*, than the inhabitants of the north, who arrive by sea\*. In travelling from Perote to Vera Cruz, the Mexicans descend in sixteen hours from the region of pines and oaks, from a mountainous country where the thermometer very often sinks at noon to four or five degrees, to a burning plain covered with cocoa trees, with *mimosa cornigera*, and other plants that vegetate only under the influence of a strong heat. These mountaineers feel a difference of temperature of eighteen degrees; and this difference produces the most fatal effects on the organs, by exciting their irritability. The European, on the contrary, crosses the Atlantic Ocean in thirty-five or forty days; he prepares himself gradually for the sweltering heats of Vera Cruz, which, without being the direct cause of the yellow fever, do not the less contribute to the rapidity of it's progress.

A very sensible decrement of heat is observed

\* *Nouv. Esp.* t. ii, p. 772.



on the Globe, whether we go from the equator to the poles, ascend from the surface of the earth into the highest regions of the air, or dive into the depth of the ocean. It is so much the more interesting to compare the rapidity of this three-fold decrement, as this phenomenon has a great influence on the climatic distributions of vegetable and animal productions. The mean temperature of the lower strata of the air, which corresponds to the sixty-fifth, forty-eighth, and twentieth, degrees of north latitude, are, according to the most recent observations,  $0\cdot5^{\circ}$ ,  $10\cdot7^{\circ}$ , and  $25^{\circ}$ ; whence it results, that a centigrade degree corresponds nearly to a change of latitude of  $1^{\circ} 45'$ \*. Now the decrement of caloric is one degree every ninety toises, when we raise ourselves perpendicularly into the atmosphere†. It therefore follows, that under the tropics, where the lowering of the temperature is very regular on mountains of considerable height, 500 toises of vertical elevation correspond to a change of latitude of  $9^{\circ} 45'$ . This result, conformable

\* In England and in Scotland it is reckoned, that a degree of Fahrenheit's thermometer corresponds to one degree of latitude. Phil. Trans. 1775, vol. lxxv, page 459. Thomson, Hist. of the Royal Soc. 1812, p. 508.

† Mr. d'Aubuisson finds only eighty-three toises to a degree for Europe in summer at eight in the morning, consequently at the period he thinks the most favourable. Journal de Phys. t. lxxi, p. 38. For the torrid zone, see Observ. Astron. t. i, p. 129.

enough to those which other naturalists have adopted before me\*, is very important to the geography of plants ; for though in the northern countries the distribution of vegetables on the mountains and in the plains depends, like the height of the perpetual snows, more on the mean temperature of the months of summer†

\* Every hundred metres of height lower the temperature about half a degree of the common division of our thermometers : and if we take for the limit of refrigeration, that which excludes the presence of vegetation, the perpetual ice, with which the summits of mountains are loaded, will represent the perpetual ice with which the pole is covered ; and every hundred metres of vertical height will correspond to a degree of the distance from the mountain to the pole. Ramond, on the Vegetation of Mountains (Annales du Museum, t. iv, p. 396).

† Decandolle, Flore française, t. i, p. 1, p. 9. Leopold von Buch, Reise nach Lapland, t. ii, p. 276. Wahlenberg, Flora Laponica, 1810, p. 28. In the temperate zone it often happens, that the mean heat of a place, *a*, is less than that of a place *b*, while the mean heat of the summer months is much greater at *a* than at *b*. It is for this reason, that a distinction is properly made between a *continental climate* and an *insular climate* ; in the first, very warm summers succeed very rigorous winters ; in the second, the contrast of the winters is less ; the summers are less warm, and the winters less cold, on account of the small changes in the temperature of the neighbouring ocean, by which the air is cooled in summer and warmed in winter. The perpetual snows descend more in Iceland than on the same parallel in the interior of Norway, and we often see, in the islands and on the coasts of western Europe, the laurel and the arbutus flourish, where the vine

than on that of the whole year, the latter does not less determine in southern countries the limits, which the species have not been able to pass in their distant migrations. The observation made by Tournefort on the summit of Ara-

and the peach tree do not ripen. In the equinoctial region, on the contrary, where the difference of the season is as it were nothing, the geographical distribution of plants is regulated almost only according to the mean temperature of the whole year, which depends itself on the elevation of the soil above the level of the ocean. In proportion as we advance toward the north, the temperature of the months varies more and more, and the strength and richness of vegetation no longer give the measure of the mean temperature of the whole year. In Lapland, for instance, there are beautiful forests on the continent, at Enontekies, while on the island of Mageroe we scarce find a few shrubs sprinkled over the rocks; nevertheless the mean annual temperature of Enontekies is three degrees colder than that of Mageroe. The former is  $-2.86^{\circ}$ , and the latter  $+0.07^{\circ}$ . (Wahlenberg, in Gilbert's Annals, 1812, p. 271.) The more vigorous vegetation of Enontekies is the effect of a warmer summer, the mean temperature of the months of July being there  $15.3^{\circ}$ ; while at the isle of Mageroe it is only, according to Mr. von Buch,  $8.2^{\circ}$ . These two places offer striking instances of the difference between a continental climate and an insular climate; or, as Mr. Wahlenberg says, between a climate of Siberia, and a climate of Iceland. In general, the problem of the climatic distribution of plants is much more complicated in the northern countries than under the tropics. In the former this distribution depends at the same time both on the mean temperature of the summer months, and on the temperature of the soil, which differs from the mean heat of the year.

rat has been repeated by a great number of travellers. When we descend from a high chain of mountains, and advance toward the poles, we find at first in plains of little height, and finally in the regions near the coasts, the same arborescent plants\*, which in the low latitudes cover only the heights near the perennial snows.

In estimating the rapidity with which the mean temperature of the atmosphere diminishes in proportion as we proceed from the equator to the poles, or from the surface of the earth to the high regions of the aerial ocean, I have considered the decrement of heat as following an arithmetrical progression. This supposition is not perfectly accurate with respect to the air†;

\* In the study of the geographical relations of plants, we must distinguish between those vegetables, the organization of which resists great changes of temperature and barometric pressure, and those plants which appear to belong only to certain zones at certain heights. This difference is still more sensible in the temperate zone than under the tropics, where the herbaceous plants are less frequent, and where the trees are stripped of their leaves only by the effect of the dryness of the air. We see some vegetables push their migrations from the northern coasts of Africa over the Pyrenees as far as the downs near Bordeaux, and the basin of the Loire; for instance, the merendera, the late-flowering hyacinth, and the hoop-petticoat narcissus, *narcissus bulbocodium*. *Annales du Mus.*, t. iv, p. 401.

† The mean temperatures augment from the equator to the poles, nearly as the square of the sine of the latitude, (*Journ.*



and is still less so for the winter, the successive strata of which seem to diminish in temperature according to different laws at different degrees of latitude. In the interesting experiments made by Forster, Bladh, Wales, Ellis, and Peron, on the rapidity of the decrement of heat in the ocean, this decrement has been found so unequal, that a degree of the centigrade thermometer answers sometimes to twelve, at other times to twenty-four toises, and even more. We may in general admit, that the temperature decreases six times as quick in the sea as in the aerial ocean, and that it is on account of this distribution of caloric in the two elements, that plants and animals analogous to those of the polar regions find under the torrid zone, on the slope of mountains, and in the depths of the ocean, the climate which is suitable to their organization.

The same causes, to which we ought to attribute the moderate heats we feel in sailing between the tropics, produce also a singular equality in the temperature of the day and the night. This equality is still greater on sea than in the interior of the continents. In the province of

de Phys., t. lxii, p. 447; and the decrement of heat, in a vertical plane, follows most frequently, according to Oriani and Lindenau, the law of harmonical progression. Tables barom. p. 45. Mon. Cor. Juin. 1805. Ephem. Med. 1788. p. 186.



Cumana, in the centre of vast plains, of small height above the level of the ocean, the thermometer is generally toward sunrise four or five degrees lower than at two in the afternoon. In the Atlantic ocean, on the contrary, between eleven and seventeen degrees of latitude, the greatest variations of heat rarely exceed 1·5 or two degrees; and I have often observed, that from ten in the morning to five in the evening the thermometer did not vary 0·8 of a degree. In looking over fourteen hundred thermometrical observations made hourly during the voyage of Mr. Krusenstern, in the equatorial region of the South Sea, we see, that the temperature of the air changed from day to night only one or 1·3 centesimal degree\*.

I have often endeavoured to measure the *power of the Sun* by two thermometers of mercury perfectly equal†, one of which remained exposed to the Sun, while the other was placed in the shade. The difference resulting from the absorption of the rays in the ball of the instru-

\* I constantly observed the thermometer on the deck, to windward, and in the shade. Perhaps the thermometer and barometer of Mr. Krusenstern were in a more sheltered place, for instance in the great cabin.

† This instrument had a ball of three lines diameter, which was not blackened. The scales were contained in tubes of glass very distant from the ball. Travellers prefer at present, and with reason, Mr. Leslie's photometers. Nicholson's Journal, 4to edition, vol. iii, p. 467.

ment never exceeded  $3.7^{\circ}$ . Sometimes it did not even rise higher than one or two degrees; but the heat in the body of the vessel, and the humid wind which blows by fits, render experiments of this kind very difficult. I have repeated them with more success on the ridge of the Cordilleras, and in the plains, by hourly comparing, in perfectly calm weather, the power of the Sun with it's height, the blue color of the sky, and the hygrometrical state of the air. We shall examine in another place, whether the variable differences observed between the thermometer in the Sun, and the thermometer in the shade, depend only on the greater or less extinction of light in it's passage through the atmosphere.

#### TEMPERATURE OF THE SEA.

In my observations on the temperature of the waters of the sea, I had in view four objects very distinct from each other; the decrement of heat in the successive strata of the air; the indication of shoals by the thermometer; the temperature of the seas at their surface; and, finally, the temperature of the currents, which, flowing from the equator \* to the poles, and from the poles to the equator, form warm or cold streams † amid the motionless waters of the

\* The Gulf-stream.

† The current of Chili, which, as I have elsewhere proved, draws the waters of the high latitudes toward the equator.

ocean. I shall treat here only of the heat of the sea at it's surface, the phenomenon of most importance to the physical history of the Globe, because the superior stratum of the ocean is the only one, that has an immediate influence on the state of our atmosphere.

The following table is extracted from the numerous experiments contained in our journal from the 9th of June to the 15th of July.

North latitude.		West longitude.		Temperat. of the Atlantic Ocean at it's surface.
39°	10'	16°	18'	15·0°
34	30	16	55	16·3
32	16	17	4	17·7
30	36	16	54	18·6
29	18	16	40	19·3
26	51	19	13	20·0
20	8	28	51	21·2
17	57	33	14	22·4
14	57	44	40	23·7
13	51	49	43	24·7
10	46	60	54	25·8

From Corunna to the mouth of the Tagus, the water of the sea varied but little in it's temperature; but from the thirty-ninth degree of latitude to the tenth, the increment was very sensible, and very constant, though not always uniform. From the parallel of Cape Montego to that of Salvage, the progress of the thermometer

was almost as rapid as from  $20^{\circ} 8'$  to  $10^{\circ} 46'$ ; but it slackened extremely on the limits of the torrid zone, from  $29^{\circ} 18'$  to  $20^{\circ} 8'$ . This inequality is no doubt caused by the currents, that mingle the waters of different latitudes, and which, according as we approach the Canary islands or the coasts of Guyana, set either to the south-east or the north-north-west. Mr. de Churruca, who crossed the equator in his voyage to the straits of Magellan, in the twenty-fifth degree of west longitude\*, found the maximum of the temperature of the Atlantic Ocean at it's surface in six degrees north latitude. In those parts, in latitudes equally distant from the equator, the water of the sea was colder to the south than the north. We shall soon see, that this phenomenon varies with the seasons, and that it depends in a great measure on the impetuosity, with which the waters run toward the north and north-west, across the channel formed between Brazil and the coasts of Africa. If the motion of these waters did not modify the temperature of the ocean, the increment of heat under the torrid zone would be enormous, because the surface of the water reflects infinitely fewer of those rays which approach the perpendicular, than of those which fall in a more oblique direction.

I have observed in the Atlantic Ocean, as well

\* In the month of October, 1783.

as in the South Sea, that, when we change both latitude and longitude at the same time, the waters often do not change one degree of temperature, in an extent of several thousand square leagues; and that in the space comprised between the twenty-seventh degree north and the twenty-seventh south, this temperature of the seas is almost entirely independant of the variations of the atmosphere \*. A very long calm, a momentary change in the duration of the currents, a tempest mingling the inferior strata of the water with the upper, may for some time produce a difference of two or even three degrees; but as soon as these accidental causes cease to act, the temperature of the ocean resumes it's former stability. I shall have occasion to return to this phenomenon, one of the most invariable that nature offers.

I have constructed a chart of the temperature of the seas, as well from my own observations, made from the forty-fourth degree of north to the twelfth degree of south latitude, and from the forty-third to the hundred and fifth of west.

\* To show what little influence the air has on the temperature of the immense basin of the seas, I have added, in the journals, the indication of the heat of the atmosphere to that of the heat of the ocean. The latter may be changed by very remote causes, such as the more or less rapid melting of the polar ice, or winds blowing in other latitudes, and producing currents.



longitude, as from a great number of materials, which I have with some difficulty collected. As a considerable body of water cools with extreme slowness, it is sufficient to plunge the thermometer into a bucket of water just taken from the surface of the ocean. Though this experiment is very simple, it has been hitherto singularly neglected. In the greater part of the narrations of voyages, the temperature of the ocean is but casually mentioned; for instance, on occasion of the researches made on the cold that prevails at great depths, or on the stream of warm water that traverses the Atlantic. I have not been able to make use of the excellent work of Mr. Kirwan *on climates*, because this celebrated naturalist has not sufficiently distinguished, in his tables of the temperature of the different latitudes, between what is the result of direct experiments, and what of theory; but the second voyage to the straits of Magellan\*, under the command of Churruca and Galeano, the relation of Abbé Chappe's Voyage to California, the work published at Philadelphia under the title of *Thermometrical Navigation*†, and particularly the interesting experiments made in 1800 by Mr. Perrins, on board the *Skelton*, in the course

\* Don Cosme de Churruca, *Apendice del Viage al Magellanes*, 1793, p. 98.

† *Thermometrical Navigation*, 1799, p. 37.

of a voyage from London to Bombay, have furnished me with numerous materials for my work.

Employed at Lima in researches on the temperature of the sea, I had engaged an officer of the royal navy, Mr. Quevedo, to observe day by day, during his passage from Peru to Spain, round Cape Horn, the heights of two thermometers, one of which should be exposed to the air, and the other plunged into the upper stratum of the ocean. The observations made by Mr. Quevedo in 1802 \*, on board the frigate Santa Rufina, which will be given in this work, embrace both temperatures, from the sixth degree of south to the thirty-sixth of north latitude; and are so much the more valuable, as this very well informed navigator knew perfectly his longitude by means of a chronometer by Brockbanks, and of the distances of the moon from the sun. His meteorological instruments, constructed by Nairne, had been compared, before his departure, with those I made use of on the Cordilleras.

From the equator to the twenty-fifth and twenty-eighth degrees of north latitude, the temperature is remarkably constant, notwithstanding the difference of the meridians; it is more variable in the high latitudes, where the melting of the polar ice, the currents caused by this melting, and the extreme obliquity of the solar rays

\* Nicholson's Journal, 1804, p. 131.

in winter, diminish the heat of the ocean. The following table, which contains experiments taken without discrimination from several nautical journals, confirms these assertions. The fractions of degrees, by which the results are expressed, arise from the reduction of the scales of the thermometer of Reaumur or Fahrenheit to the centigrade division.

TABLE of the  
Temperature of the Atlantic Ocean in different degrees of longitude.

Latitude.	Longitude.	Temperature of the Ocean.	Period of the observation.	Observers.	Mean temperature of the air in the basin of the seas.
0° 58' S.	27° 34' W.	27·2°	Nov. 1788	Churruca	27° (Cook).
0 57 S.	30 11 W.	27·7	April 1803	Quevedo	
0 33 S.	21 20 W.	27·7	March 1800	Perrins	
0 11 N.	84 15 W.	28·0	Febr. 1803	Humboldt	
0 13 N.	51 42 E.	27·1	May 1800	Perrins	
25° 15' N.	20° 36' W.	20·0°	June 1799	Humboldt	21° (La Pérouse and Dalrymple).
25 29 N.	39 54 W.	21·6	April 1803	Quevedo	
25 49 N.	26 20 W.	20·7	March 1800	Perrins	
27 40 N.	17 4 W.	21·6	Jan. 1768	Chappe	
28 47 N.	18 17 W.	23·5	Octob. 1788	Churruca	
42° 34' N.	15° 45' W.	11·1°	Febr. 1800	Perrins	12 7° (Cook and d'Entrecasteaux).
43 17 N.	31 27 W.	15·5	May 1803	Quevedo	
43 58 N.	13 7 W.	15·9	June 1799	Humboldt	
44 58 N.	34 47 W.	12·7	Dec. 1789	Williams	
45 13 N.	4 40 W.	15·5	Nov. 1776	Franklin	
48 11 N.	14 18 W.	14·3	June 1790	Williams	

It is very remarkable, that, notwithstanding the immensity of the ocean, and the rapidity of the currents, there is a great uniformity every where in the maximum of heat in the equinoctial seas. Mr. Churruca found this maximum, in 1788, in the Atlantic Ocean, at  $28.7^{\circ}$ ; Mr. Perrins, in 1804, at  $28.2^{\circ}$ ; Mr. Rodman \*, in his voyage from Philadelphia to Batavia, at  $28.8^{\circ}$ ; and Mr. Quevedo, at  $28.6^{\circ}$ . In the South Sea I observed it the same year at  $29.3^{\circ}$ ; consequently, the differences scarcely exceed  $1^{\circ}$  of the centigrade thermometer, or  $\frac{1}{26}$  of the total heat. We must recollect, that, under the temperate zone, to the north of the parallel of  $45^{\circ}$ , the mean temperatures of different years vary more than  $2^{\circ}$ , or a fifth of the quantity of caloric that a determinate part of the Globe † receives.

\* Coxe, Philadelphian Medical Museum, vol. i, p. 82.

† Geneva from 1796 to 1809;  $7.87^{\circ}$ ;  $8.34^{\circ}$ ;  $8^{\circ}$ ;  $7.47^{\circ}$ ;  $8.38^{\circ}$ ;  $8.49^{\circ}$ ;  $8.49^{\circ}$ ;  $8.27^{\circ}$ ;  $8.5^{\circ}$ ;  $7.12^{\circ}$ ;  $8.73^{\circ}$ ;  $7.78^{\circ}$ ;  $6.68^{\circ}$ , and  $7.54^{\circ}$  of Reaumur's thermometer: Paris, at the Observatory, from 1803 to 1810;  $11.95^{\circ}$ ;  $10.75^{\circ}$ ;  $10.35^{\circ}$ ;  $10.55^{\circ}$ ;  $10.50^{\circ}$ ;  $10.65^{\circ}$ ;  $11.10^{\circ}$ ; and  $9.79^{\circ}$  of the centigrade thermometer. In proportion as we approach the tropics, the variations of the annual temperature diminish. Rome (lat.  $41^{\circ} 53'$ ) from 1789 to 1792;  $13.6^{\circ}$ ;  $12.5^{\circ}$ ;  $13.4^{\circ}$ ; and  $12.9^{\circ}$ , Reaum. (Buch. in Gilbert's Annalen der Physik, t. 24, p. 238). Philadelphia, (lat.  $39^{\circ} 56'$ ) from 1797 to 1803.  $12.7^{\circ}$ ;  $11.6^{\circ}$ ;  $11.8^{\circ}$ ;  $11.7^{\circ}$ ;  $12.7^{\circ}$ ; and  $12.8^{\circ}$  of the centigrade thermometer. From these very accurate observations it results, that the extremes at Geneva have been  $2.5^{\circ}$ ; at Paris  $2.2^{\circ}$ ; at Rome,  $1.3^{\circ}$ ; and at Philadelphia,  $1.1^{\circ}$  of the



The maximum of the temperature of the seas, which is from 28 to 29 degrees, proves more than any other consideration, that the ocean is in general warmer than the atmosphere with which it is immediately in contact, and of which the mean temperature, near the equator, is from 26 to 27 degrees. An equilibrium between the two elements cannot be established ; not only on account of the winds, which carry the air near the poles toward the equator, but also in consequence of the absorption of caloric, the effect of evaporation. It is so much the more extraordinary to see the mean temperature rise, in a part of the equatorial ocean, beyond  $29^{\circ}$  ( $23\cdot2^{\circ}$  R.) ; as even on the continents, amidst the most arid sands, we scarcely know a place, where the mean heat of the year reaches to  $31^{\circ}$ .

It remains to be examined, whether in the low latitudes, in the same parallels, we find, in different seasons, nearly the same temperatures. The following table will facilitate this kind of research.

centesimal division. The variations observed in the temperature of the sea at it's surface seemed to extend, under the temperate zone, between the 35th and 45th degrees of latitude, to three degrees above and below it's mean temperature ; and I was wrong in saying, in a general manner, in the introduction to Thomson's Chemistry (French translation, t. i, p. 100), that the ocean every where directly indicates the mean temperatures of the air, corresponding to the different latitudes.

TABLE  
Of the Temperature of the Atlantic Ocean in different seasons.

North Latitude.	Centigrade Thermometer and West Longitude.					
	Chappe Jan. and Feb. 1768.	Perrins, March, 1804.	Quevedo, April and May, 1803.	Humboldt, June and July, 1799.	Churruca, October, 1788.	Rodman, Oct. and Nov. 1803.
34½°	{ . . . . .	Th. 16° Lg. 18° 20'	Th. 18·8° Lg. 41° 11'	Th. 16·3° Lg. 16° 55'	Th. 23·4° Lg. 10° 37'	Th. 24·3° Lg. 52° 40'
30°	{ Th. 20·7° Lg. 9° 30'	Th. 19·3° Lg. 23° 15'	Th. 20·7° Lg. 38° 40'	Th. 18·4° Lg. 16° 50'	Th. 23·8° Lg. 16° 4'	. . . . .
26°	{ Th. 23·9° Lg. 18° 10'	Th. 20·7° Lg. 26° 20'	Th. 21·2° Lg. 39° 54'	Th. 20·2° Lg. 19° 45'	. . . . .	Th. 25·0° Lg. 35° 20'
18°	{ . . . . .	Th. 22·7° Lg. 28° 32'	Th. 23·2° Lg. 41° 17'	Th. 22·4° Lg. 32° 10'	Th. 26·4° Lg. 22° 10'	Th. 26·2° Lg. 29° 50'
10°	{ . . . . .	Th. 23·8° Lg. 24° 30'	Th. 26·2° Lg. 37° 7'	Th. 25·8° Lg. 65° 40'	Th. 28·2° Lg. 22° 25'	Th. 28·2° Lg. 26° 50'

TABLE of the Temperature of the Atlantic Ocean, &c. *continued.*

North Latitude.	Centigrade Thermometer and West Longitude.					
	Chappe, Jan. and Feb. 1768.	Perrins. March, 1804.	Quevedo, April and May, 1803.	Humboldt, June and July, 1799.	Churruca, October, 1788.	Rodman, Oct. and Nov. 1803.
5°	{ . . . . .	Th. 26·5° Lg. 22° 33'	Th. 26·5° Lg. 33° 10'	. . . . . . . . .	Th. 28·3° Lg. 22° 27'	Th. 28·8° Lg. 25° 10'
Maximum of the temperature of the Ocean.	{ . . . . .	Th. 28·2°, in 0° 15' of north lat. and 22° 21' of west long.	Th. 28·6°, in 2° 2' of south lat. and 29° 40' of west long.	. . . . . . . . .	Th. 28·7° in 6° 15' of north lat. and 22° 12' of west long.	Th. 28·8° from 8° 40' to 5° 45' of north lat. and from 25° 50' to 25° 0' of west long.

A great mass of water follows with extreme slowness the changes of temperature observed in the atmosphere, and the maximum of the mean temperatures of each month does not occur at the same time in the ocean and in the air. The increment of the heat of the seas necessarily undergoes a delay; and as the temperature of the air begins to diminish, before that of the water has reached it's maximum, it follows, that the extent of the thermometrical variations is smaller at the surface of the sea than in the atmosphere. We are still very far from knowing the laws of these phenomena, which have a great influence in the economy of nature.

Mr. Kirwan admits, that between the eighteenth degree of north and the eighteenth of south latitude, the mean temperatures of the months differ only five centesimal degrees, and this estimation is somewhat too low; for we know by observations, carefully calculated, that at Pondicherry, at Manilla, and in several other places between the tropics, the mean heats of the months of January and August differ eight or ten degrees. Now the variations of the air are at least a third less in the basin of the seas, than on the continent; and the ocean undergoes a part only of the changes of temperature of the atmosphere that surrounds it. Hence it results, that, if the equinoctial oceans did not communicate with the seas of the tem-

perate zones, the local influence of the seasons would be almost nothing in it.

Mr. Peron \*, who has very successfully repeated the experiments made by Ellis, Forster, and Irvine, on the cold that prevails at the bottom of the ocean, affirms, " that every where the open sea is colder at noon, and warmer at night, than the surrounding air." This assertion has need of much restriction ; I am ignorant whether it be exact in the forty-fourth and forty-ninth degrees of south latitude, where this laborious naturalist appears to have made the greatest number of his thermometrical observations ; but between the tropics, where the air in the open sea is scarcely two or three degrees colder at midnight than two hours after the culmination of the Sun, I have never found the least change in the temperature of the ocean, either day or night. This difference is sensible only in a dead calm, during which the surface of the water absorbs a greater mass of rays ; but we have already observed, that the thermometrical experiments made in this state of the ocean relate to a local phenomenon only, and ought to be entirely excluded in discussing a problem of general physics.

The observations contained in the preceding

\* *Annales du Museum*, t. v. p. 123—143. *Journ. de Phys.* t. lix, p. 361. *Gilbert, Annalen der Physik*, t. xix. p. 427.



tables have all been collected under the same parallels, but in very different longitudes and seasons. At the time of the voyage to the Magellanick regions, and to Batavia, the *maximum* of the temperature was found much more to the north than it had been perceived in all the other voyages; which has had a sensible influence on the heat of the sea to the north of the tropic of Cancer. The *maximum*, according to Churruca and Rodman, was in October, in six degrees north; according to Mr. Quevedo, in March, in  $20^{\circ} 2'$  south; and according to Dr. Perrins, in April, in  $0^{\circ} 15'$  north. I observed it in March, at the east of the Galipago islands, in  $2^{\circ} 27'$  of north latitude. It is probable, that changes in the currents cause these extraordinary anomalies; and that the great circle, which passes through the points where the water of the sea is the warmest, cuts the equator at an angle which is variable according as the declination of the Sun is north or south. These phenomena, connected perhaps with those of the limit of the trade winds, and the *maximum* of the saltness of the sea, deserved to be carefully examined; but we should not be surprised at a failure of accurate observations on the temperature of the equatorial seas, if we recollect, that we are still ignorant of the thermometrical variations in the neighbouring seas of Europe\*.

\* Since my return in 1804, I have in vain exhorted those

From the thirtieth degree of north latitude, the results which I attained agree very well with the observations of Perrins and Quevedo. It is not probably to the local influence of the seasons, as we have just proved, but to the motion of the waters, and to remote causes, that we must attribute the extent of the variations of temperature observed between the tropics in the voyage from London to Bombay. These variations have risen to five degrees, while in the South Sea I found them only  $2.7^{\circ}$ . Quevedo, in traversing from south to north a space of six hundred and forty leagues, saw the heat of the Atlantic ocean from the tropic of Capricorn to the ninth degree of north latitude, change only

naturalists, who inhabit the coasts of the ocean, in Spain, in France, and in England, to ascertain, for each month in the year, the mean temperature of the sea at its surface, compared with the mean temperature of the air on the neighbouring coasts. What has been published on this subject is founded either on theoretical considerations, or on a small number of experiments, which have not been made in the open sea, but in harbours, and sheltered roads. What is the maximum of cold which the ocean attains in the forty-fifth degree of latitude, taking the mean average of several days? to what month does this maximum correspond? It is asserted, that, near Marseilles, the sea is never colder than  $6.5^{\circ}$ , or warmer than  $25^{\circ}$ ; though the extremes of the temperature of the air are often  $-4^{\circ}$  and  $+35^{\circ}$  (*Mém. de la Soc. Royal de Med.* 1778, p. 70). Can it be admitted, that, in the open sea, the heat of the Atlantic rises to  $20^{\circ}$  in latitude  $45^{\circ}$ .

1·7°; and as far as the twenty-third of north latitude, the greatest variation of the sea extended no farther than 3·7°.

This great regularity in the distribution of the heat of the ocean is manifested also in a very sensible manner, when we compare, in the two hemispheres, zones equally distant from the equator.

TABLE.

Comparison of the Temperature of the Seas in both Hemispheres.

Latitude.	Longitude.	Period of the Observation.	Temp. of the Ocean at it's surface. (Cent. Th.)	Names of the Observers.	Mean temp. of the air observed on the Continents.	Remarks. (The temperat. of the Ocean is nearly equal to the mean atmosph. temp. of the month; the temp. of the air expresses the mean heat of the year under different parallels.)
3° 53' N.	90° 36' W.	February . 1803	28·7°	Humboldt	} 27° to 28° }	} South Sea.
3 16 S.	86 23 W.	January . 1803	27·0	<i>Idem.</i> . . .		
4 8 N.	22 54 W.	October . 1788	27·5	Churruca	} . . . . }	} Atlantic Ocean.
3 44 S.	28 10 W.	November 1788	27·0	<i>Idem.</i> . . .		
4 36 N.	53 50 E.	May . . 1800	27·6	Perrins	} . . . . }	} Indian Sea.
4 44 S.	24 51 W.	April . . 1800	26·4	<i>Idem.</i> . . .		
11 12 N.	37 41 W.	April . . 1803	27·1	Quevedo .	} . . . . }	} Atlantic Ocean.
11 32 S.	29 41 W.	March . 1803	27·0	<i>Idem.</i> . . .		
11 58 N.	25 26 W.	March . 1800	23·2	Perrins . .	} 25·28° }	} Atlantic Ocean.
12 30 S.	27 20 W.	April . . 1800	25·8	<i>Idem.</i> . . .		

Latitude.	Longitude.	Period of the Observation.	Temp. of the Ocean at it's surface. (Cent. Th.)	Names of the Observers.	Mean temp. of the air observed on the Continents.	Remarks. (The temperat. of the Ocean is nearly equal to the mean atmospheric temp. of the <i>month</i> ; the temp. of the air expresses the mean heat of the <i>year</i> under different parallels.)
15° 24' N. 15 50 S.	30° 44' W. 30 34 W.	April . . 1803 March . 1803	23·8° 26·5	Quevedo . <i>Idem</i> . .	. . . .	} Atlantic Ocean.
23 0 N. 23 40 N. 22 52 N. 23 23 S. 23 28 S. 23 30 S.	26 50 W. 41 6 W. 22 13 W. 28 58 W. 29 40 W. 50 10 E.	March . 1800 April . 1803 June . 1799 March . 1803 April . 1800 May . . 1800	21·0 22·1 20·0 27·0 25·5 22·0	Perrins . Quevedo Humboldt Quevedo . Perrins . <i>Idem</i> . .	23° . . . . .	} Atlantic Ocean.     } Indian Sea.
31 0 N. 31 22 N. 31 58 N. 31 30 N. 31 34 S. 31 0 S. 31 34 S. 31 4 S.	79 37 W. 15 7 W. 20 10 W. 38 45 W. 28 29 W. 26 20 W. 46 56 W. 47 40 E.	May . . 1804 October 1788 March . 1800 April . . 1803 March . 1803 April . . 1800 November 1788 May . . 1800	21·5 23·6 17·7 20·7 24·3 20·5 20·5 19·4	Humboldt Churruca Perrins . Quevedo . <i>Idem</i> . . Perrins . Churruca. Perrins .	21·6 . . . . . . .	} Atlantic Ocean.       } Indian Sea.



Latitude.	Longitude.	Period of the Observation.	Temp. of the Ocean at its surface. (Cent. Th.)	Names of the Observers.	Mean temp. of the air observed on the Continents.	Remarks. (The temperat. of the Ocean is nearly equal to the mean atmospheric temp. of the <i>month</i> ; the temp. of the air expresses the mean heat of the <i>year</i> under different parallels.)
36° 38' N.	41° 2' W.	May . . 1803	19.3°	Quevedo .	19.8°	Atlantic Ocean.
36 5 N.	76 41 W.	May . . 1803	20.0	Humboldt		
36 4 N.	17 5 W.	June . . 1799	15.2	<i>Idem</i> . .		
33 16 N.	10 24 W.	October 1788	23.4	Churruca .		
35 22 S.	50 32 W.	November 1788	17.0	<i>Idem</i> . .		
36 3 S.	17 3 W.	April . . 1800	18.8	Perrins . .		
36 5 S.	41 58 W.	May . . 1803	20.0	Quevedo .		
33 52 S.	94 52 W.	February 1803	22.0	<i>Idem</i> . .		
40 28 N.	33 35 W.	May . . 1803	17.1	Quevedo .	17.5°	Atlantic Ocean.
40 30 N.	68 36 W.	July . . 1804	18.7	Humboldt		
42 34 N.	15 45 W.	February 1800	11.2	Perrins . .		
42 30 S.	50 30 W.	March . 1803	13.2	Quevedo .		
40 36 S.	48 20 W.	March . 1803	15.5	<i>Idem</i> . .		
40 48 S.	93 56 W.	February 1803	17.0	<i>Idem</i> . .		South Sea.

In discussing these observations made at different seasons, we should compare the months, which in both hemispheres are almost equally distant from the solstices. It is necessary also to pay attention to the slowness, with which, in the temperate zone, the sea receives and loses the heat communicated to it by the air. The anomalies that take place proceed perhaps in part from the variations, which the mean atmospheric temperatures of the months undergo on the same spot, but in different years.

The preceding table shows, that the ideas which are generally formed of the low temperature of the southern hemisphere are not perfectly accurate. Near the poles, and in very high latitudes, the cold of the seas is undoubtedly less to the north than the south of the equator; but this difference is not sensible between the tropics; it is even very little perceptible as far as the 35th and 40th degrees of latitude.

Mr. Kirwan obtained an analogous result for the air that rests on the ocean, by taking the averages of a great number of observations made during the winter and summer in each hemisphere, and recorded in the journals of navigators\*. From the equator to the thirty-fourth

\* See a very interesting paper by him in the Transactions of the Irish Academy, vol. viii, p. 422.

degree of south latitude, the winters are more temperate than under the same parallels in the northern hemisphere; and even in fifty one degrees south, at the Falkland Islands, the month of July is much less cold than the month of January at London.

TABLE.

*Comparison of the temperature of the air in both hemispheres\*.*

Latitude.	Correspondent Months.	Mean temp. of the Months.	
		Southern hemisphere.	Northern hemisphere.
0°—15°	December . . . . June . . . . .	28·0° . . . . .	. . . . . 28·5°
18	October . . . . April . . . . .	. . . . . 27·5	26·5 . . . . .
2°—26	January . . . . July . . . . .	. . . . . 22·5	19·3 . . . . .
	September . . . . March . . . . .	. . . . . 20·8	20·5 . . . . .
34	December . . . . June . . . . .	. . . . . 13·8	15·4 . . . . .
	February . . . . August . . . . .	. . . . . 16·8	17·0 . . . . .
43	July . . . . . January . . . . .	. . . . . 15·2	18·2 . . . . .
48	June . . . . . December . . . . .	. . . . . 7	17·7 . . . . .
58	July . . . . . January . . . . .	. . . . . 6·2	13·5 . . . . .

\* The observations employed in constructing this table

These investigations are highly interesting to the physical history of our planet. Does the quantity of free caloric remain the same during thousands of years ? have the mean temperatures corresponding to different parallels augmented, or diminished, since the last revolution that altered the surface of the Globe ? We cannot answer these questions in the present state of our knowledge ; we are ignorant of every thing that relates to a general change of the climates, as we know not whether the barometric pressure of the atmosphere, the quantity of oxygen, the intensity of the magnetic powers, and a great number of other phenomena, have undergone any change since the time of Noah, of Xisuthris, or Menou. As a local variation in the temperature of the ocean at it's surface might be the effect of a progressive change in the direction of the currents, which bring hotter or colder water, according as they come from lower or higher latitudes ; so, in a very limited extent of sea, a similar refrigeration might be produced by the conflict of oblique and submarine currents, which mix the waters of the bottom with those at the surface ; but we can draw no general conclusions from changes that have taken place on a

were all made at sea, except those, from which the mean temperature for the latitude of  $34^{\circ}$  was deduced. For these we are indebted to Mr. Sparmann, during his stay at the Cape of Good Hope.



few points of the Globe, whether at the surface of the sea, or on the continent\*. It is only by the comparison of a great number of observations, made in different parallels of latitude, and at different degrees of longitude, that we shall be able to solve the important problem of the increase or diminution of the heat of the Earth.

As a preparation for this work, we must carefully determine, at a given period, the *maximum* of the temperature of the waters of the sea under the tropics, and in the *parallel of the warmest waters*. We have proved, that this maximum is at present, in places the most remote from each other, from  $28^{\circ}$  to  $29^{\circ}$  of the centigrade thermometer. Very distant posterity will one day decide, whether, as Mr. Leslie† has endeavoured to prove by ingenious hypotheses, two thousand four hundred years are sufficient to augment the mean temperature of the atmosphere a single degree. However slow this increment may be,

\* The currents of the aerial ocean act like the currents of the sea. In Europe, for instance, the mean temperature of a place may augment, because very remote causes make a change in the equilibrium between the winds of the south-west and those of the north-east. We may even conceive a partial change in the mean barometric height of a place, without this phenomenon indicating any general revolution in the constitution of the atmosphere.

† An experimental Inquiry into the Nature and Propagation of Heat, 1804, p. 181, and 536.

we must admit, that an hypothesis, according to which organic life seems gradually to augment on the Globe, occupies more agreeably our imagination, than the old system of the cooling of our planet, and the accumulation of the polar ice. Some parts of physics and geology are merely conjectural ; and it might be said, that science would lose much of it's attraction, if we endeavoured to confine this conjectual part within too narrow limits.

#### HYGROMETRICAL STATE OF THE AIR.

Notwithstanding the doubts which have been raised in these latter times respecting the accuracy, with which hair or whalebone hygrometers indicate the quantity of vapours mingled in the atmospheric air, it must be admitted, that, even in the present state of our knowledge, these instruments are highly interesting to a naturalist, who can transport them from the temperate to the torrid zone, from the northern to the southern hemisphere, from the low regions of the air that rest on the sea to the snowy tops of the Cordilleras. I would rather, says Mr. de Saussure\*, that the most imperfect instrument were made use of, a hempen string with a stone suspended to it, than entirely neglect researches,

\* Essai sur l'Hygrométrie, § 353.

for which so little has been done in distant voyages\*. Without entering into the question, whether inaccurate experiments are more injurious to the progress of the sciences than the total ignorance of a certain number of facts, I may affirm, that several hygrometers, constructed by Mr. Paul at Geneva, and reduced from time to time to the point of extreme humidity†, have

\* Mr. Peron thinks, “ that it was in the voyage of Captain Baudin, that hygrometers for the first time crossed the ocean.” But before this voyage, and even a long time before my own, hygrometrical observations had been made in the voyage of Lapérouse, and at Bengal by the son of Mr. Deluc.

† I made this correction every time that I had any doubt of the indication of the hygrometer. I employed immersion in rain water, as Mr. Deluc recommends for whalebone. It is known, that this method of verification, even with hair, can cause but a slight error of  $1^{\circ}$  or  $1.5^{\circ}$  (Essai, § 32, p. 37); while the best hygrometers often differ from each other two degrees. I have never been able to reduce the hair or whalebone to the degree of extreme siccity, for want of a portable apparatus, which I regret not having made before my departure. I advise travellers to provide themselves with a narrow jar, containing caustic potash, quicklime, or muriat of lime, and closed with a screw by a plate on which the hygrometer may be fixed. This small apparatus would be of easy conveyance, if care were taken to keep it always in a perpendicular position. As under the tropics Saussure’s hygrometer generally keeps above  $85^{\circ}$ , a frequent verification of the single point of extreme humidity is most commonly sufficient to give confidence to the observer. Besides, in order to know on which side the error lies, we should recollect, that old hygrometers, if not corrected, have a tendency to indicate too great dryness.

furnished me with observations which accorded very well with each other. I have always preferred the old instrument with a single hair to that of Richer, in which several hairs act at the same time on the index, and with unequal tensions. I can affirm also, that every thing Mr. de Saussure has advanced, in his Essay on Hygrometry, of the long duration of his portable hygrometers, is extremely exact\*. I have preserved some without any alteration during three years travels in the forests and mountains of South America. Before my departure they were compared by Mr. Pictet with the hygrometers of the observatory at Geneva; and I have almost always found them at  $99^{\circ}$  or  $100.5^{\circ}$ , when I have been able to expose them to a very thick fog.

As the fiftieth degree of the whalebone hygrometer corresponds to the eighty-sixth degree of the hair hygrometer, I made use of the first at sea and in the plains, while the second was generally reserved for the dry air of the Cordilleras. The hair below the sixty-fifth degree of Saussure's instrument indicates, by great variations, the smallest changes of dryness; and has besides the advantage of putting itself more rapidly into a state of equilibrium with the ambient air. Deluc's hygrometer acts, on the contrary, with

\* Ibid. § 67.

extreme slowness ; and on the summit of mountains, as I have frequently experienced to my great regret, we are often uncertain whether we have not ceased our observations before the instrument has ceased it's movement. On the other hand, this hygrometer, furnished with a spring, has the advantages of being strong, marking with great exactness in very moist air the least increment of the quantity of vapor in solution, and acting in all positions ; while Saussure's hygrometer must be suspended, and is often deranged by the wind, which raises the counterpoise of the index. I have thought it might prove useful to travellers, to mention in this place the results of an experience of several years.

During the whole of the passage, the apparent humidity of the atmosphere, that indicated by the hygrometer not corrected by the temperature, augmented sensibly, notwithstanding the progressive increment of the heat. In the month of July, in the thirteenth and fourteenth degrees of latitude, Saussure's hygrometer marked at sea from eighty-eight to ninety-two degrees\*, in per-

\* The hair hygrometer being much better known than that of whalebone, in order to preserve a uniform rate, the hygrometrical results have been given according to Saussure's instrument, even when the observations were made with that of Deluc. It is only in the meteorological journal, that the hygrometer employed for each series of experiments is men-



fectly serene weather, the thermometer being at twenty-four degrees. On the banks of the lake of Geneva\*, the mean humidity of the same month is only eighty degrees, the average heat being nineteen degrees. Now, on reducing these hygrometrical observations to a uniform temperature, we find, that the real humidity, in the equinoctial basin of the Atlantic Ocean, is to the humidity of the months of summer, at Geneva, in the ratio of twelve to seven. This enormous humidity of the atmosphere explains in a great measure the strength of vegetation, which we admire on the coasts of South America, where no rain falls for several years.

As the quantity of vapors changes, not with the elasticity of the air, but with the temperature, we may compare, either the absolute quantities of vapour contained in the atmosphere in two places, or the proportion of their quantities to those necessary to the complete saturation of the air in different climates. We know by very accurate experiments the capacities of saturation of the air at different degrees of the thermometer; but the relations which exist between the progressive lengthening of a hygroscopical body, tioned. The numbers always mark the apparent humidity, if the contrary be not expressly stated.

\* Under the temperate zone, on the continent, the extremes were commonly in summer sixty-seven and eighty-eight degrees, the temperature of the air being from twenty-six to eighteen centesimal degrees.

and the quantities of vapor contained in a given space, have not been appreciated with the same degree of certainty. These considerations have induced me to publish the indications of the hair and whalebone hygrometers just as they were observed, marking the degree shown by the thermometers connected with these two instruments. To facilitate to a certain point the comparison of the observations made in different latitudes, I shall here insert a table, which was calculated by Mr. d'Aubuisson, when he made his valuable researches on the coefficients of the barometric formulas. The whole of the results prove that as we advance toward the equator, the air approaches the point of saturation. We have chosen the periods, when the temperature of the sea was nearly equal to that of the air. Of eight columns, which compose this table, the first contains the time of the observation: the second the latitude of the place; the third the state of the thermometer; the fourth the state of the hygrometer; the fifth the weight of vapor contained in a cubic metre of air, supposing it saturated; the sixth the weight of vapor contained in a cubic metre of air, at the degree of the hygrometer observed; the seventh the thickness of the sheet of water which should be evaporated in an hour's time, if the surrounding air was perfectly dry; the eighth the same

thickness, admitting in the air the quantity of vapor indicated by the hygrometer\*.

\* The following is the basis of Mr. d'Aubuisson's calculation :

$t$  = the height of the centigrade thermometer.

$\mu$  = the height of de Saussure's hygrometer.

Let  $a =$   
 $b =$   
 $c =$   
 $d =$

the quantities indicated in the columns of the following table, and designated by the same letters.

$\phi$  = Elastic force of the vapour in a space which is saturated.

According to the observations of Saussure, it is found, that the elastic force, in a space in which the hygrometer marks  $\mu$  degrees is  $\phi$  ( $0.015 \mu - 0.47$ ), while  $\mu > 50^\circ$ . Let  $0.015 \mu - 0.47 = m$ .

Mr. La Place gives, from the experiments of Dalton,

$$\phi = 0.005123 \times (10)^{\text{met.}} t. 0.0279712 - + 30.000062483.$$

(*Méc. cél.* t. iv. p. 273.) Hence it is concluded :

$$a = \phi \frac{1221.8}{1 + t. 0.00375} ; b = a \times m ; c = \phi \frac{\text{millim.}}{42} ; \text{ and } d = c (1 - m).$$

TABLE.

*Results of the Hygrometrical Observations made in the basin of the Atlantic Ocean.*

Periods of the observation.	Latitude of the place in the open sea.	Data.		Quantity of vapor contained. in the air.		Quantity of water evaporated in an hour's time.	
		Therm.	Hygrom.	to saturation. a) grammes.	in reality. b) grammes.	the air being dry. c) millim.	in reality d) millim.
9 June 1799	39° 10'	14.5	82°	14.6	11.4	0.53	0.13
15 . . .	30 36	20.0	85.7	20.0	16.2	0.74	0.14
16 . . .	29 18	20.0	83.8	20.0	15.7	0.74	0.16
30 . . .	18 53	21.2	81.5	21.3	16.0	0.79	0.20
4 July . . .	16 19	22.5	88	22.9	19.4	0.85	0.13
10 . . .	12 34	24.0	89	24.8	21.5	0.93	0.13
12 . . .	10 46	25.4	90	26.7	23.5	1.01	0.12
14 . . .	1 1	25	92	26.8	23.8	0.98	0.09

It follows from these researches, that, if the quantity of vapor, which the air commonly contains in our middle latitudes, amounts to about three quarters of the quantity necessary for its saturation, in the torrid zone this quantity is raised to nine-tenths. The exact ratio is from 0.78 to 0.88. It is this great humidity of the air, under the tropics, which is the cause that the evaporation is less than we should have supposed it to be from the elevation of the temperature.

I was often surprised, during this passage, and at a later period in the vast basin of the Pacific Ocean, at not seeing the hygrometer make nearer approaches to the point of extreme humidity. This instrument has been sometimes, far from the coasts, at eighty-three degrees; and generally in the equinoctial zone, it kept between ninety and ninety-two degrees. According to the meteorological tables, published by Messrs. Langsdorff and Horner, we see, that in Krusenstern's voyage, as well as in that of La Pérouse, the apparent humidity \* was found to be

\* *Mém. de l'Acad. de Pétersbourg*, t. i, p. 454. I have corrected the indications of Deluc's hygrometer, which was used by the Russian navigators. In their instrument the 76th degree corresponded to the point of extreme humidity. Lamanon's hygrometers were well verified, since they indicated 100 or 101 degrees in a thick fog. *Voyage de La Pérouse*, t. iv, p. 261.



from eighty-eight to ninety-two degrees. The extremes were eighty-three and ninety-seven degrees, which is conformable to my observations. It is true, that, from the curious researches of Mr. Gay-Lussac, the hygrometer can never indicate beyond ninety degrees in air in contact with a saturated solution of muriat of soda ; but the water of the sea is every where so distant from the point of saturation, that the salt which it contains would scarcely change a single degree the point of the greatest humidity, that the lower strata of the air in the basin of the seas might attain. This point would be indicated by the hygrometer, if the tranquillity of the atmosphere were not troubled by currents.

The wind, in displacing the particles of the air, does not make the hair rise to dry, as it causes the descent of a thermometer exposed to the sun by carrying off the strata of air strongly heated. Numerous experiments \* of Mr. de Saussure prove, that the air acts in the same manner on hygroscopic substances, whether it be in motion or at rest ; consequently the influence of horizontal or descending winds becomes sensible to the hygrometer inasmuch only as these winds bring strata of air less loaded with vapors. If oblique currents are established, either by a sudden acceleration in the decre-

\* Essai sur l'Hygrométrie, § 150—156.

ment of caloric, or by the conflict of several winds, or by electric phenomena, the upper strata of the atmosphere are mingled with the lower strata. These movements, joined to the horizontal winds that traverse great continents before they reach the basis of the seas, perpetually tend to remove the hygrometer from the extreme point of saturation. Perhaps also the polar currents, which, from the effects of the rotation of the Globe, seem to produce the appearance of trade winds, have too much velocity to suffer the air they bring, to load itself under each parallel with the whole quantity of vapor correspondent to it's temperature.

Naturalists, who have long marked the progress of the hygrometer in the open air, have seldom seen these instruments at a hundred degrees, except in a thick fog. In the heaviest rain, even in the midst of the clouds, the hair hygrometer often keeps at ninety and ninety-five degrees \*. In this case the air placed between

\* Mr. de Saussure observed it once at  $84.7^{\circ}$  during a very heavy shower. *Essai*, § 326, p. 321. On the other hand, Mr. Deluc found, that his hygrometers, which, plunged into water, marked 100, kept at  $83.3^{\circ}$  when they were placed under a glass jar filled with atmospheric air, and of which the sides were constantly moistened. On seeing in my journal, that Deluc's hygrometer kept oftenest between sixty and sixty-three degrees, it should be remembered, that in this instrument the point of saturation *in the air* is not a hundred, but about eighty-four or eighty-five degrees. *Idées sur la*

the drops of water, or the vesicular vapor, is far from being saturated; and I doubt whether the atmosphere, preserving a perfect transparency, ever attains the maximum of humidity, which we obtain under our glass jars. Mr. de Saussure, after having explained the long series of his manometrical and hygrometrical experiments, made at different degrees of temperature, admits, that the last degrees of his instrument are perhaps only *degrees of supersaturation*, and that the quantity of vapor that a certain volume of free air can contain, is probably less than might be admitted from the experiments made in our laboratories \*.

The naturalists, who accompanied the Chevalier Krusenstern in his voyage round the world, assert, that Deluc's hygrometer enabled the mariners to foresee stormy weather, during the passage from Washington Islands to Sanga-sacky; and in all other parts of the torrid zone, where the changes of the atmosphere have scarcely any influence on the barometer. Mr. Peron,

Metéorologie, 1786, t. i, p. 72; t. ii, p. 473. Urenna, Anales de Historia natural, 1803, p. 229.

\* In determining the point of extreme humidity, it is supposed, that the air in the jar is not yet saturated, when the vapors begin to be precipitated in an almost imperceptible manner. (Saussure, Essai, § 107 and 123.) Mr. Gay-Lussac has shown, that the hygroscopical property of the glass becomes a source of errors difficult to avoid.

on the other hand, says, that he has seen the barometer constantly fall at sea, when the hair hygrometer advanced toward extreme humidity. I have had no opportunity of verifying either of these assertions.

AZURE COLOR OF THE SKY, AND COLOR OF THE  
SEA AT IT'S SURFACE.

The cyanometrical indications contained in this work are, I believe, the first that have been attempted on the sea, and in the equinoctial regions. The instrument I made use of had been compared with that of Mr. de Saussure. I had the satisfaction, in 1795, to consult this illustrious naturalist on my travelling projects; and he had engaged me to make, at a distance from Europe, a series of observations similar to those he had collected on the chain of the higher Alps\*.

I shall not here enter into the theory of the cyanometer, and the necessary precautions to avoid errors. Though this imperfect instrument is yet but little known, naturalists are not less acquainted with the ingenious principle, on which the determination of the extreme points of the scale † are founded. In order to assure myself

\* Mr. Leslie has expressed the same desire in his work on the propagation of heat, p. 442.

† Mémoires de Turin, t. iv, p. 409. Journal de Physique,



by direct proof, whether the cyanometrical observations are comparable with each other, I have often placed the instrument in the hands of persons, who had not been accustomed to this kind of measurement, and I have observed, that their judgment on the shades of blue toward the horizon and at the zenith never differed more than two degrees.

The chamois hunters and Swiss herdsmen have at all times been struck with the intense color of the heavenly vault on the summit of the Alps. In the year 1765 Mr. Deluc fixed the attention of naturalists on the phenomenon, the causes of which he developed with equal precision and simplicity. "In the lower part of the atmosphere," says he \*, "the color of the air is always paler and weakened by the vapors, which at the same time cause a greater dispersion of the light. The air of the plains becomes deeper, when it is more pure; but it never approaches the vivid and deep tint, which is remarked on the

t. xxxviii, p. 499. Voyages dans les Alpes, § 2036. Essai sur la Géographie des Plantes, 1807, p. 102. Bouguer appears to have already had the idea of a similar instrument, but of more general use. In speaking of the light reflected by the particles of the air, he says, "We should employ, as a term of comparison, painted tablets of different colors." *Traité d'Optique*, p. 365.

\* *Researches on the Modifications of the Atmosphere*, § 931.



mountains." It seemed to me, that in the chain of the Andes these appearances make less impression on the mind of the natives, because those among them, who scale the summits of the Cordilleras to gather snow, do not come from the region of the low lands, but from elevated plains, which are themselves twelve or fifteen hundred toises above the level of the sea.

I found on examining the cyanometrical observations recorded in my journal, that, from the coasts of Spain and Africa to those of South-America, the azure color of the heavenly vault progressively augmented from thirteen to twenty-three degrees. From the 8th to the 12th of July, in twelve and a half and fourteen degrees of latitude, the sky was of an extraordinary paleness, without any concrete or vesicular vapor being visible. The cyanometer indicated at the zenith, between noon and two in the afternoon\*, only sixteen or seventeen degrees; though the

\* The observations were always made at the zenith itself, or near the zenith, but at times when the Sun was distant from that part of the sky, of which the intensity of the blue color was measured. At ten or twelve degrees distance around the sun, the tint has a local paleness; as on the contrary it has a local intensity, when the blue of the sky is seen, either between two clouds, or above a mountain covered with snow, or between the sails of a ship, or the tops of trees. It is scarcely necessary to remark, that this intensity is only apparent, and that it is the effect of a contrast of two colors of different shades.

preceding days it had been at twenty-two degrees. I found in general the tint of the sky deeper under the torrid zone, than in the high latitudes ; but I have also proved, that, in the same parallel, this tint is paler at sea than on land.

As the color of the firmament depends on the accumulation and on the nature of the opaque vapors suspended in the air, we should not be astonished, if during great droughts, in the *steppes* of Venezuela and of Meta, we see the sky of a deeper blue than in the basin of the ocean. A very hot air, almost saturated with humidity, rises perpetually from the seas toward the high regions of the atmosphere, where a colder temperature prevails. This ascending current causes there a precipitation, or rather a condensation of vapor. Part assembles in clouds, under the form of vesicular vapor, at times when we see no clouds appear in the dryer air that reposes on the land ; another part remains scattered, and suspended in the atmosphere, the tint of which it renders paler. When, from the summit of the Andes, we turn our eye toward the great South Sea, we often perceive a haziness uniformly spread to fifteen or eighteen hundred toises in height, and covering, as with a thin veil, the surface of the ocean. This appearance takes place in a season when the atmosphere, beheld from the coast and at sea, appears pure and

perfectly transparent ; and the existence of the opaque vapor is announced to navigators only by the little intensity of the azure color of the sky. We shall hereafter have occasion to return to these phenomena, which modify the extinction of light ; and which, like the fogs popularly called dry, remain so confined to the high regions of the atmosphere, that our hygrometers undergo no sensible change.

I have often repeated, in the equinoctial part of the Atlantic Ocean, the experiments of Mr. de Saussure on the decrement of the intensity of color observed from the zenith to the horizon. On the 14th of July, in latitude  $16^{\circ} 19'$ , the sky being of the purest blue, the thermometer keeping at twenty-two degrees, and the hygrometer at eighty-eight degrees, I found, toward noon,

at $1^{\circ}$ of height, $3^{\circ}$ of the cyanometer	
10	6
20	10
30	16.5
40	18
60	22
between 70 & 90	23.5

The 30th of June, in latitude  $18^{\circ} 58'$ , the thermometer being at  $21.2^{\circ}$ , and the hygrometer at  $81.5^{\circ}$ , the cyanometric decrement had been somewhat less regular :

at $1^{\circ}$ of height, $2.5^{\circ}$ of the cyanometer	
10	4

at 20° of height, 8·5° of the cyanometer

30	12
45	15·5
50	18·3
60	21
between 70 & 90	22·4

This decrement has a great analogy with that which was observed at Geneva on the 11th of April, 1790, and to which Mr. Prevost \* endeavoured to apply calculation. We know, that both follow nearly an arithmetical progression, but that at sea there are great irregularities before twenty degrees of height. This zone near the horizon exhibits tints extremely pale, on account of the vapor that lies on the surface of the water, and through which the blue rays are transmitted to us. It is for the same reason, that near the coasts, at an equal distance from the zenith, the vault of the sky appears of a deeper color on the land side than on that toward the sea.

The quantity of vapor, which modifies the shades of the atmosphere by reflecting white light, is changing from morning to evening ; and the cyanometer, observed at the zenith, or near this point, indicates with sufficient precision the variations that correspond to the different hours of the day.



Latitude.	6½ o'clock.	10 o'clock.	Noon.	2 o'clock.	5½ o'clock.
18° 53'	17°	21°	22·4°	22°	18°
16 19	19	22	23·5	23	20·5
13 51	15	16	17	17	15·8

I was unwilling to omit the last observation, that of the 8th of July, though the sky, by a singular anomaly, appeared that day as pale as we see it on the continent in the temperate zone. The Sun being at equal distances from the meridian, the tints are deeper in the evening than in the morning, without doubt because the maximum of temperature falls between the hours of one and two. I have not remarked, like Mr. de Saussure, that the cyanometer was regularly less elevated at noon\*, than some time before the passage of the Sun across the meridian; but I have not been able to devote myself with the same assiduity to this kind of investigation.

We must not confound the cyanometrical measures with the experiments, which Bouguer attempted, by means of his *lucimeter*, on the intensity of the light diffused or reflected by the air. This intensity contributes without doubt to modify the more or less azure tint of the heavenly vault; but the two phenomena do not depend directly on the same causes, and there

\* Cyanometrical observations at Geneva:

6 o'clock.	10 o'clock.	Noon.	2 o'clock.	6 o'clock.
14·7°	22·6°	22·5°	20·6°	17°



are a great number of circumstances, in which the intensity of the aerial light is very small while the cyanometer indicates deeper tints. Mr. Leslie\* has observed, for instance, by his photometer, that the light diffused is weaker, when the sky is of a very deep and pure blue, than when it is slightly covered by transparent vapor. So, on the mountains where the intensity of the direct light is the greatest †, the aerial light is very weak, because the rays are reflected by air of less density. A very deep tint corresponds there to the feebleness of the diffused light; and the aspect of the sky on the mountains would resemble that offered by the heavenly vault on the plains, when it is illuminated by the feeble light of the Moon, if the state of the aqueous vapor did not produce a sensible difference in the quantity of white rays reflected toward the lower regions of the Earth. In these regions, the vapors are condensed after sunset, and the descending currents disturb that equilibrium of temperature, which has been established during the day. On the ridge of the Cordilleras, the azure of the sky is less mingled with white, because the air there is always extremely dry. The rarer atmosphere of the mountains, illumined by the vivid light of the Sun, reflects

\* On the Propagation of Heat, p. 441.

† Laplace, *Mécan. Céleste*, t. iv, p. 282. *Expos. du Syst. du Monde*, p. 96.

setting. This disk, beheld across the strata of air that lie immediately upon the ocean, announces the duration of fine weather, and the slackness or strength of the wind. It is a kind of diaphanometer\*, the indications of which have been interpreted with greater or less certainty for ages. Under the torrid zone, where the meteorological phenomena follow each other with great regularity, and where the horizontal refractions are more uniform, the prognostics are surer than in the northern regions. A great paleness of the setting Sun, a wan color, an extraordinary disfiguration of it's disk, are almost unequivocal signs of a tempest ; and we can scarcely conceive, how the state of the low strata of the atmosphere, which this natural diaphanometer shows us, can be so intimately connected with meteorological changes, that take place eight or ten hours after the setting of the Sun.

Mariners have carried the physiognomical knowledge of the sky to a much higher state of perfection, than the inhabitants of the fields. Viewing only the ocean, and the sky which seems to repose upon it's surface, their attention is continually fixed on the slightest modifications of the atmosphere. Among the great number of meteorological rules, which pilots trans-

\* See the description of the apparatus, to which Saussure has given this name in the *Mémoires de Turin*, vol. iv. p. 425.

mit to each other as a kind of inheritance, there are several that evince great sagacity ; and, in general, prognostics are less uncertain in the basin of the seas, especially in the equinoctial parts of the ocean, than on the continent, where the configuration of the ground, mountains, and plains, interrupts the regularity of the meteorological phenomena. The influence of the lunations on the duration of tempests ; the action exercised by the Moon at it's rising, during several successive days, on the dissolution of the clouds ; the intimate connection that exists between the descent of marine barometers and the changes of weather ; and other similar facts ; are scarcely observed in inland countries comprised in the variable zone, while their reality cannot be denied by those, who have long been in the habit of sailing between the tropics.

I attempted to apply the cyanometer to measure the color of the sea. Though this color is commonly green, we have no need of a *chlorometer* to estimate the intensity of it's tint. In this experiment there is no question but of the strength of the color, of the lighter or deeper shade, and not of the individual nature or quality of the tint. In fine calm weather the color of the ocean has been equal to the thirty-third, the thirty-eighth, sometimes even the forty-fourth degree of the cyanometer ; though the vault of the sky was very pale, and scarcely reached the

fourteenth or fifteenth degree. It would be useless to repeat these experiments when the atmosphere is loaded with clouds, or in the shadow of a vessel. When, instead of directing the cyanometer toward a great extent of open sea, we fix our eyes on a small part of it's surface through a narrow aperture, the water appears of a beautiful ultramarine color. Toward evening, on the contrary, when the edges of the waves, illumined by the Sun, are of an emerald green, their surface, on the shady side, has a purple reflection.

Nothing is more striking than the rapid changes, which the ocean undergoes beneath a serene sky, where no variations whatever are to be perceived in the atmosphere. I do not here speak of the whitish and milky tint, that marks the waters of shoals, and in soundings, which is owing only to the sand suspended in the liquid, since it is perceived in places, where the bottom, in twenty or thirty fathoms water, is no way visible ; I speak of those extraordinary changes, by which, in the midst of the vast basin of the equinoctial ocean, the water passes from an indigo blue to the deepest green, and from this to a slate gray, without any apparent influence from the azure of the sky, or the color of the clouds.

The blue tint of the ocean is almost independent of the reflection of the sky. In general the sea between the tropics is of a more intense and



purser azure than in high latitudes ; and this difference is remarked even in the Gulf-stream. The ocean often remains blue, when, in fine weather, more than four-fifths of the sky are covered with light and floating clouds. They who do not admit Newton's theory of colors consider the blue of the sky as the black of space seen through a medium, the transparency of which is disturbed by vapors \* : this explanation they might extend to the blue tint of the Ocean.

Whatever relates to the color of the water is extremely problematic. The green tint of the snow waters, that flow from the glaciers of the Alps, and which contain very little air in solution, might induce us to believe, that this color is appropriate to water in it's greatest purity. We address ourselves in vain to chemistry to explain this phenomenon, or that of the blue color of the Rhone near Geneva : there is hitherto no proof, that waters exist which contain a greater or less degree of hydrogen ; and the refrigeration of the seas in tempests is much too weak, to permit us to attribute the reflection of different colored rays to the mere change of density. It is no way probable, that the green color of the water is owing to the mixture of yellow rays from the bottom, and blue rays reflected by the

\* Antonio de Dominis, la Hire, and Mr. von Goethe (*Mém. de l'Acad.*, t. ix, p. 615. *Farbenlehre*, t. i, p. 59.)



water \*; for the open sea is often green, where it is more than eight hundred fathoms deep. Perhaps, at certain hours of the day, the red or yellow light of the Sun contributes to the colouring it green †. The waves, like moveable and inclined mirrors, progressively reflect the shades and tints of the atmosphere from the zenith to the horizon. The motion of the surface of the water modifies the quantity of light, that penetrates toward the inferior strata; and it may be conceived, that those rapid changes of transmission, which act as it were like changes of opakeness, may, when they are united to other causes unknown to us, change the tint of the ocean.

#### DIP OF THE MAGNETIC NEEDLE. INTENSITY OF THE MAGNETIC FORCES.

The variations of terrestrial magnetism belong to a kind of phenomena, on which I have employed myself with singular predilection, during the course of my travels, and in the subsequent years. The objects to which I directed my researches were, first, the dip of the magnetic needle; secondly, the variation, or angle which

\* *Décade Egyptienne*, vol. i, p. 101.

† The beautiful greenish blue color of ice, when we see it in a great mass, is a phenomenon well worthy of investigation, and known by every naturalist, who has visited the glaciers of the Alps.

the magnetic meridian makes with the meridian of the place; thirdly, the horary variations of the variation; fourthly, the intensity of the magnetic forces, measured by the duration of the oscillation of a horizontal or vertical needle \*. The extent of the surface of the Globe, in which I have been enabled to determine the magnetic phenomena with the same instruments, and employing similar methods, was one hundred and fifteen degrees in longitude, and is comprised between fifty-two degrees north and twelve degrees south latitude. This vast region is so much the more interesting, as it is traversed by the magnetic equator; so that the point where the dip is nought, having been determined by land, and by astronomical means, we may, with respect to the two Americas, convert, with precision, the terrestrial latitudes into

\* When we measure the intensity by the oscillations of a needle in a horizontal plane, we must correct the results by the dip observed in the same place. This correction is unnecessary, when we employ a dipping needle, which oscillates in the plane of the magnetic meridian. The number also of these oscillations, compared with the number of those which the same needle makes in a plane perpendicular to the magnetic meridian, determines the dip of the place. This method of finding the dip by an instrument without a divided limb affords more precision near the magnetic equator, than in the northern regions: it served to verify the exactness of a part of my observations, published before my return to Europe by Mr. de La Lande. (*Journal de Phys.*, vol. xlix, p. 429.)

magnetic latitudes. This conversion, indispensable for the study of the complicated laws of magnetism, is, on the contrary, very problematic, when we compare observations of the magnetic dip made in meridians very remote from each other ; and when we consider the magnetic equator as a great circle, without inflection, and without irregularity of curve.

Notwithstanding the considerable degree of perfection, which Mitchell and Nairne had attained in the construction of dipping needles, these instruments, before the year 1791, had not reached that degree of exactness, which they have now attained. If La Caille, Dalrymple, Cook, Bayly, and Lord Mulgrave have succeeded in obtaining excellent results, it is because these able observers made numerous comparative experiments, and took the average of a great number. The compasses employed in La Perouse's expedition were those made use of by Captain Cook in his last voyage round the world. We must suppose, that these instruments were out of order, or of difficult use : for the dips observed on board the *Astralabe* often differ five, six, or eight degrees from those obtained the same day on board the *Boussole*. This uncertainty had induced the celebrated Borda to apply himself, conjointly with Mr. Le Noir, to the improvement of the dipping needle. This navigator, to whom astronomy is indebted

for the use of repeating circles, has also furnished travellers with the means of making accurate observations on the magnetic dip. Borda's compass was successfully employed in the voyage of Viceadmiral d'Entrecasteaux, in that of Captain Baudin, and in the excursions of Mr. Nouet in Egypt. If we add the results obtained in these different voyages to those I have collected during seven years in the two divisions of America, in Spain, France, Italy, Switzerland, and Germany, we shall have a great mass of observations, comparable\* with each other,

\* The observations of the dipping needle made by de Ros-sel, Freycinet, Nouet, Gay-Lussac, and myself, are so much the more adapted to be compared with each other, as they embrace but a very short portion of time. Le Monnier (*Lois du Magnétisme*, p. 57) and Lord Mulgrave (*Voyage to the North Pole*, p. 68) still admitted the invariability of the magnetic dip : but Messrs. Gilpin and Cavendish proved, in 1806, by direct experiments, that the dip of the needle is subject, like the variation, to annual oscillations, though extremely slow. The cities of London and Paris are hitherto the only places, where the extent of these oscillations is known. The dip at London, in 1775, was  $72^{\circ} 30'$  and in 1805,  $70^{\circ} 21'$  (Phil. Trans., vol. lxvi, pl. 1, p. 401). We cannot admit, with P. Cotte (Journ. de Physique, t. lxvi, p. 277), that, before the year 1808, the dip of the magnetic needle was not known with precision at Paris. I had determined it with a great deal of care, conjointly with Mr. de Borda, in 1798, before my departure for Spain. It was then  $69^{\circ} 51'$ . Mr. Gay-Lussac found it in 1806,  $69^{\circ} 12'$ . On the 7th of October, 1810, the dip at Paris was  $68^{\circ} 50'$ ; and on the 10th

and worthy of exercising the sagacity of geometers.

Though our passage from Corunna to Cumana lasted thirty-seven days, I could collect, during this space of time, only twelve good observations of the magnetic dip. I had caused an addition to be made to Borda's compass, by an able artist of Madrid, Mr. Megnié, of a suspension with a double movable ring, like that known under the name of Cardan's suspension. By these means the instrument might be tied by a very long cord to a part of the poop, which appeared nearly free from iron, and where small portions of this metal were very equally distributed. I ascertained the advantages of this position by determining the dip during a dead calm, on the deck, and in several parts of the vessel below. During the course of those observations, I found the direction of the magnetic meridian in seeking the

of November, 1812,  $68^{\circ} 42'$ . The first of these two experiments was made by Mr. Arago and myself; the second by Mr. Arago alone. The particular observations did not differ three or four minutes. The poles of the needle were changed several times; and all imaginable precautions were employed, in the use of Borda's compass, to avoid errors. From these observations it results, that from 1775 to 1805 the dip diminished at London  $4' 1''$  yearly: at Paris the annual diminution, from 1798 to 1812, was  $4' 54''$ . I should think it hazardous to go back to anterior times, when the instruments were too imperfect, and when observers employed too little nicety in their magnetic experiments.



minimum of the dips. Most commonly I had to judge of the magnitude of the angle by taking, among a great number of very small oscillations, the mean of the elongations toward the north and the south. I constantly employed two different needles; their centring was verified by comparing the indications of the two extremities of the same needle, and inverting it, or successively directing the divided face of the limb east and west. I think I may be certain, that observations made when under sail may attain an average exactness of twelve minutes of the centesimal division \*.

\* The angles given by Borda's dipping compass are expressed in centesimal degrees and decimal parts. The verifications of the instrument, which can be made on land, and which I have constantly employed with Mr. Gay-Lussac, during the course of the observations published in the *Memoirs of the Society of Arcueil*, are reducible to the following: 1st, giving a horizontal position to the azimuth circle, by means of a bubble level, and a thread level; 2ndly, finding the direction of the magnetic meridian, either *a*) by correspondent dips, or *b*) by adding, on the azimuth circle, one hundred degrees to the point which corresponds to the perpendicular position of the needle; or finally *c*) by the *minimum* of the dips; 3dly, correcting the eccentricity of the needle, by observing the superior and inferior points; 4thly, examining whether the magnetic axis of the needle coincides with its physical axis, by observations to the east and the west; 5thly, correcting the want of equilibrium in the needle by changing the poles. The slight differences, which will be noticed between the results published in this narrative, and

those that were inserted, during my journey, in several public papers (*Journ. de Phys.* t. iv, p. 433; *Mag. Encyclop. an.* 3, p. 376; *Zach. Monatl. Corresp.* t. i, p. 402), arise from my having sometimes neglected taking the average between the observations made to the east and the west, and because the latitudes and longitudes observed had not always been reduced by estimation to the same time, when the magnetic dip had been determined.

*Dip of the Magnetic Needle, and Intensity of the Magnetic Forces  
in the North Atlantic Ocean, in 1799.*

117

North Latitude.	West Longitude.	Magnetic Dip. Centesimal Divisions.	Numb. of Oscillations in 10 minutes.	Remarks.
38° 52'	16° 22'	75.76°	242	Good observation.
37 26	16 32	75.35	242	Almost perfect calm.
34 30	16 55	73.00	234	Perfect calm.
31 46	17 4	71.90	237	Doubtful, especially the intensity.
28 28	18 33	69.35	238	Good.
24 53	20 58	67.60	239	Very good.
21 29	25 42	64.65	237	Good.
19 54	28 45	63.52	236	Good.
14 15	48 3	56.30	239	Good.
13 2	53 15	50.67	234	Dip good. Intensity doubtful.
11 1	54 51	47.05	237	Good.
10 46	60 54	46.95	229	Good.

Part of these observations served as a basis to the theories and calculations of Messrs. Loewen-oern, Biot, and Kraft \* ; they give the direction of the equator, or of the magnetic parallels, with so much the more precision, as I took the same pains in examining the dip, as in ascertaining the geographical position of the vessel. The most accurate observations on the variation of the needle, on it's dip, and on the intensity of the magnetic forces, would be of little value, if the traveller were not provided with the instruments necessary to ascertain astronomically the latitude and longitude of the place where the different phenomena of terrestrial magnetism were observed.

I shall not speak of the attempt I made during the passage, to determine the curves of the magnetic variation. The results obtained at sea by the best azimuth compasses are so uncertain, that, according to the testimony of the most experienced navigators †, errors of two or three degrees often occur. Even supposing them only one degree, this uncertainty, augmented by

\* Danske Vid. Selskabs Scrivter, 1802, p. 295. Journ. de Phys. t. lix, p. 287. Mém. de Pétersbourg, 1809, t. i, p. 248. See also Mollweide's Attempt to generalize the Theories of Euler and Mayer, in Gilbert's Annalen, t. xxix, p. 1 and 251.

† Voy. de Vancouver, t. i, p. 40 and 99. De Rossel, in the Voy. de d'Entrecasteaux, t. ii, p. 172. Cooke's second Voyage, vol. i, p. 24.

the slow changes of the variation in different meridians, would still throw much doubt over the real position of the curves, which are attempted to be traced on variation charts \*.

On comparing the observations made during several voyages, it appears, that we had cut the curve of no variation in latitude  $13^{\circ}$  north, and longitude  $53^{\circ}$  and  $65^{\circ}$  west: this curve is now prolonged toward Cape Hatteras, and toward a point in Canada, in  $33^{\circ} 27'$  north latitude, and  $70^{\circ} 44'$  west longitude. Before the first voyage of Christopher Columbus, in 1460, the variation was nought near the island of Corvo, but the progress of the curve of no variation toward the west is not the same in all its parts, and it is sometimes retarded by the local influence of the continents and islands, which form so many particular systems of magnetic forces. Thus it seemed stopped for some time by the southern extremity of New Holland; and at Jamaica and Barbadoes the variation has not undergone any

\* The uncertainty of the observations of the magnetic needle made at sea does not arise solely from the rolling and pitching of the vessel, or the imperfection of the azimuth compasses; it is in a great measure caused by the masses of iron spread through the vessel, and acting unequally, according to the direction in which it is steered. Loewenoern, in the *Nye Samling of Danske Vid. Selsk. Skr.* t. iii, p. 117, and t. v, p. 299. *Zach. Mon. Cor.* 1800, p. 529. *Flinders*, in the *Phil. Trans.* 1805, p. 187.



perceptible changes for one hundred and forty years past\*.

The intensity of the magnetic forces is another very important phenomenon, to which naturalists have hitherto very little attended. Graham and Musschenbroeck had attempted to measure the diurnal variations of this force by the velocity of the horizontal oscillations of a magnetic bar †; but it appears, that Borda was the first, who had the idea of making the same dipping needle oscillate in different places of the Globe. The attempts of this learned navigator did not afford, as he has often assured me, any precise result, on account of the friction, which the ancient needles underwent on their axis. At this period men were often satisfied with making the needle of the variation compass oscillate: and in the manuscript account of Borda's Voyage to the Canaries it is expressly stated, in speaking of the modifications of the intensity of the magnetic forces measured by the velocity of the oscillations, that, at the summit of the Peak, he had counted ten oscillations of the card in 97'' of time; while at Santa Cruz their duration had been 94'', at Cadiz 103'', and at Brest 113''. Mr.

\* Thomson's Hist. of the Royal Soc., p. 461. Phil. Trans. vol. 50, p. 330 and 349. (The Oriental Navigator, 1801, p. 650.)

† Phil. Trans. vol. xxxiii, p. 332. Thomson's Hist. of the Royal Soc., p. 461. Diss. de Magnete, Exp. 102 and 107

Le Monnier, in his work on the *Laws of Magnetism*\*, observes how desirable it would be, to know the relation between the oscillations of the same needle at Peru, and in the north of Europe ; but a note added to his magnetic planisphere† shows, that he had not a very accurate idea of the causes, which modify the intensity of the total force. According to Cavendish‡, this intensity must be the same over the whole surface of the Globe ; and the opinion of this great natural philosopher must have had a very considerable influence on those, who had not had an opportunity of interrogating nature by direct experiments.

In this state of uncertainty, the Academy of Sciences at Paris very earnestly exhorted Mr. La Pérouse to make, during the course of his voyage round the world, experiments on the intensity of the magnetic forces. “ It is known,” say the commissioners §, in the instructions communicated to the naturalists engaged in the expedition, “ that at Brest, Cadiz, Teneriffe, Goree on the coast of Africa, and Guadaloupe, the intensity is sensibly the same. It would be interesting to repeat these experiments, reckoning the magnetic force by the duration of the oscillations of a good dipping needle, at sea, in very

\* Introduction, p. 25.

† Mém. de Paris, 1786, p. 43.

‡ Phil. Trans., 1778, p. 390.

§ Voyage de La Pérouse, t. i, p. 160.

calm weather. It would be above all important to know the magnetic force, where the dip is the smallest." The imperfection of the compasses put on board Mr. La Pérouse's vessels no doubt prevented the astronomers in this expedition from paying attention to investigations of this kind, and the wishes of the academy of sciences were fulfilled only in the voyage of d'Entrecasteaux, and in that of which this work gives the narrative. Among the great number of valuable observations for which we are indebted to Mr. Rossel, there are five on the oscillations of the magnetic needle \* made at Brest, at Teneriffe, at Van Diemen's Land, at Amboyna, and at Java. For my part, I have determined, jointly with Messrs. Gay-Lussac and Bonpland, from  $5^{\circ}$  of magnetic latitude south, to  $60^{\circ}$  magnetic latitude north, the intensity of the forces in a hundred and eighty places belonging to two systems of particular attractions †. In the space

\* These observations were published only in 1808 (Voy. de d'Entrecasteaux, t. ii, p. 287, 291, 321, 480, and 644) ; but they were made eight years before my journey to the Oroonoko. I was acquainted with them as early as the year 1805, immediately after having communicated to the first class of the Institute the general results of the progressive decrement of the magnetic forces from Paris to the magnetic equator. See the memoir, which I published at that time, conjointly with Mr. Biot, in the sixtieth vol. of the *Journ. de Physique*.

† On account of the inflexions of the magnetic equator, we

of three years, I have been enabled to procure the oscillation of the same needles, or needles compared with each other, at Lima, under the magnetic equator, at Mexico, at Naples, and at Berlin, which afforded me the means of determining the relation that exists between the magnetic *charges* of the Globe in different climates. From these extensive operations, an account of which will be separately published, it follows, that, supposing the intensity of the forces under the equator = 1, this intensity is, at Naples, 1.2745; at Paris, 1.3482; and at Berlin, 1.3703.

We see already, that from the thirty-eighth to the thirteenth degree of terrestrial latitude, in the part of the northern Atlantic Ocean to which the preceding table refers, the number of the oscillations diminishes from 242 to 234, while the dip varies from  $75.76^{\circ}$  to  $50.67^{\circ}$  of the centesimal division. I endeavoured to make these observations in calm weather, and when the vessel oscillated in a plane perpendicular to the plane of the limb of the compass. The oscillations of the needle are scarcely disturbed by those of the vessel, the latter having, in a uniform wind, all

may consider the points of the Globe that differ little in magnetic longitude as belonging to one system of forces. The longitudes are computed from the point of intersection between the terrestrial and magnetic equators.

the regularity of an isochronous pendulum. In general the rate, which the magnetic variations and the dip follow in different longitudes, appears more regular in the basin of the sea, than on continents where the inequalities of the surface, and the nature of the rocks of which the surrounding mountains are composed, cause frequent anomalies. As to the duration of the oscillations, it sometimes undergoes irregularities, even in the middle of the seas\*; no doubt because the stratum of water is too thin, to prevent the needle from being affected by the unequal distribution of the magnetic forces in the interior of the Globe. The mathematical theory of the tides, it is true, makes it probable, that the mean depth of the ocean is at least four leagues†; but we know, from the aerostatic voyage of Mr. Gay-Lussac, that in rising perpendicularly from the surface of the Earth 3600 toises, no sensible change is perceived in the intensity of the magnetism. We cannot therefore admit, that the sea is much deeper in those latitudes, where, under the same magnetic parallel, we see the number of oscillations diminish.

I did not regret my not having embarked the

\* See, in the Journal, my observations made in  $34^{\circ} 30'$  and  $14^{\circ} 15'$  of north latitude.

† From the small height of the tides, in open seas, and the ratio of the density of the sea to that of the land. (La Place, in the *Mém. de Paris*, 1776, p. 218.)



apparatus, which Saussure calls a *magnetometer*\*, and which Mr. Paul constructed for me at Geneva. I am inclined to think, that the variations of intensity, believed to have been seen in the same place, by means of this complicated instrument, were the effect of involuntary illusion. Mr. de Saussure thought, that the magnetic force diminished both on the mountains and during the great heats of summer, while Mr. Blondeau† believed, that he had found by an instrument of his own invention, that a high temperature of the atmosphere increased the intensity of the magnetism. Neither of these assertions has been confirmed by accurate experiments. There is no doubt, that periodical variations in the intensity of the magnetic forces exist in the same place; as have already been discovered in the variation, and even to a certain point in the dip‡ of the magnetic needle; but these varia-

\* Voyage dans les Alpes, § 458 and 2103. I find the first notion of a magnetometrical apparatus in Hooke's posthumous works. This natural philosopher, a man of extraordinary sagacity, thought, in 1680, of measuring, by means of a steelyard (*statera*), the force with which a magnet attracts iron at different distances. *Posth. Works*, p. 23. See also Brook Taylor's experiments, made in 1715, *Phil. Trans.* vol. xxxi, p. 204.

† On the apparatus, which Mr. Blondeau called magnetometer, before Saussure, see *Mém. de l'Académie de la Marine de Brest*, t. i, p. 421.

‡ Horary and diurnal variations of the dip have not yet.

tions of intensity appear to be infinitely feeble, since they cannot be perceived, if we employ, instead of the magnetometer with a perpendicular rod terminated by a ball of iron, the delicate apparatus of Coulumb, that is, the oscillations of a small needle contained in a glass case, and suspended by an untwisted silk thread\*.

been observed; but a slow change takes place in the space of several years.

\* At the hospice of Mount Cenis, and at Rome, Mr. Gay-Lussac and myself have observed the oscillations of the same needle by day and by night, in very different atmospherical temperatures. The result of these experiments was, that, if there exists a horary variation in the intensity of the magnetic forces, it does not alter the duration of the oscillations a twelve hundredth. At Milan, the same needle made, on the 15th of April, 1805, in the interior of the city, near the cathedral, sixty oscillations in  $4' 56.8''$ ; and on the 7th of October, in a meadow without the walls, in  $4' 56.4''$ . At Rome the duration of the oscillations was the same to a few tenths of a second, at the Villa Borghese, at Monte-Pincio, and on the road to Tivoli. Experiments of this sort are susceptible of so great an exactness, that in different experiments made on the top of Mount Cenis, two hundred and fifty oscillations lasted  $1229.3''$ ,  $1229.2''$ ,  $1229''$ , and  $1229.5''$ . At Rome we successively found, with a chronometer of Breguet,  $1169.2''$ ,  $1169.2''$ ,  $1169''$ , and  $1169.5''$ . I have thought it right to note in this place these results, in order to prove, that the experiments made on the intensity of the magnetic forces, and recorded in this work, are not subject, in a small extent of ground, to that great number of local and horary influences, which affect the observations on the variation of the magnetic needle.

Besides, the two instruments are not founded precisely on the same principle ; for the artificial magnet having a quantity of fluid, which is as it were independent of that of the Earth, it may be conceived, that the magnetometer, conveyed to different climates, cannot give the same results as the oscillatory apparatus.

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In speaking of the physical observations made during the passage from Ferrol to Cumana, I have not mentioned my experiments on the purity of the air, and it's electric charge\*. The former were made by means of the nitrous gas in the narrow tubes of Fontana's eudiometer, and seemed to indicate a greater portion of oxygen in the strata of the atmosphere lying on the sea, than in those which surround continents. We know at present, that, if eudiometrical variations exist, they must be less than two thousandths ; and that the results I obtained in 1799 do not merit confidence, on account of the too imperfect means then employed in the analysis of the atmosphere.

\* I took the greater interest in this kind of experiments, because, a short time before my departure from Germany, I had devoted myself to a very extensive inquiry into atmospheric electricity at the foot of the high mountains of Salzburg. The results of my labours are related in the *Journal de Physique*, an 7.

With respect to the electrometrical experiments, it was impossible for us, either on board the Pizarro, or any other vessel in which we afterward sailed, to perceive at sea the least sign of tension, on making use of Bennet's and Saussure's excellent electrometers. Mr. Bonpland has often taken the pains to carry these instruments, furnished with long metallic stems and a lighted match, on the masts and yards farthest from the hull of the vessel. These trials were repeated in the South Sea, on board a Spanish frigate with very high masts ; but the gold leaf, the dryest straws, or little balls of elder pith, which are electroscopical substances, never indicated the slightest divergence. Is it the surface of the ocean, that deprives the lower strata of the atmosphere of it's electricity ? or do the hull of the vessel, the sails, and masts, act as powerful conductors ? If this action take place, why did not our electrometers indicate electricity in open boats, while, on the coasts of Peru, we have seen signs of a strong tension, when a damp wind blew from the sea ?

It is the duty of a natural philosopher candidly to relate the circumstances in which certain experiments did not succeed. As two thirds of our atmosphere lie on the basin of the seas, meteorology would gain considerably, if we knew the electric state of this part of the aerial ocean. We may be tempted to repeat the experiments I

have just described with the microelectrometers of Weiss, Gersdorf, and Maréchaux\*. These instruments discover electricity near a wall, in the shade of a tree, every where almost, when Bennet's and Saussure's electrometers indicate none. They are preferable to electric points fastened to flying kites, or small balloons, because the electricity marked by these last, is most frequently the mere result of the ascending motion, as has been proved by the fine experiments of Mr. Erman†.

I have had no better success than the majority of travellers in ascertaining the degree of saltiness of the sea‡, which varies with the latitude. From the small number of accurate observations I obtained by means of an areometer by Dollond, differing little from that of Nicholson, it follows, that the specific gravity of the sea water augments pretty regularly from the coasts of Galicia to Teneriffe, while it diminishes

\* *Gilbert, Annalen, B. xv, p. 98.*

† *Ibid. p. 389 and 503.*

‡ Mr. Proust, struck with the traces of mercury which he had met with in all the muriats of soda of Spain (*Nicholson's Journ. of Nat. Phil.*, 4to ed., vol. iii, p. 376), requested me, at my departure from Madrid, to suspend, during the passage, a thin plate of gold or silver, to the poop of the vessel, to see if it would offer any traces of amalgama. I followed the advice of this celebrated chemist, though I had little confidence in the success of this experiment; but the thread, to which the plate was tied, broke a few days after I had put my apparatus into the water.



anew from latitude  $22^{\circ} 52'$  to  $18^{\circ} 45'$ . In these regions, in the twenty-fourth and thirtieth degrees of longitude, a large stripe of the ocean is less salt than the rest.

The muriat of soda amounts to 0.028 from the parallel of  $18^{\circ} 8'$  to that of  $12^{\circ} 34'$ , between the thirtieth and fifty-fourth degrees of longitude. It seemed to me, that, in the part of the Atlantic comprised between the coasts of Portugal and Cumana, the water is a little salter to the south of the tropic of Cancer, than under the temperate zone; and I should be induced to generalize this fact, if the experiments made during Cook's last voyage did not peremptorily prove, that this difference does not exist in every meridian. Horizontal currents, which cross the ocean at it's surface; and oblique currents which mingle the strata of water, placed at different depths; modify the saltiness of the seas; and supposing even, that the absolute quantity of the muriats dissolved in the ocean has not been augmented by the action of submarine volcanoes, but has remained the same for thousands of years, it is not the less probable, that the distribution of this salt in different parts of the Globe, undergoes, from time to time, considerable changes.

## JOURNAL

OF A

## VOYAGE FROM THE COASTS OF SPAIN

TO THOSE OF

## SOUTH AMERICA,

OR FROM

## CORUNNA TO CUMANA.

[*The longitude was found by a time-keeper of Lewis Berthoud, No. 27. The temperature of the ocean indicated is that of the surface of the water. The cyanometrical observations were made at the zenith. The thermometer exposed to the air was placed to the windward, and in the shade. When an observation of the Sun at the meridian could not be obtained, Douwe's method of double altitudes was employed. The latitudes and longitudes are given for noon.*]

Days of the month.	North latitude.	West long.	PHYSICAL OBSERVATIONS.
1799 June 5	43° 28'	10° 45'	Departure from the port of Corunna. Temperature of the ocean, 15·4° centesimal : air 10·2°. Hygrometer, whalebone, 44°, or 80·4° of Saussure's hair hygrometer.

Days of the month.	North lat.	West long.	PHYSICAL OBSERVATIONS.
June 5	43° 28'	10, 45'	<i>Cyanometer</i> , 13°. Floating clouds ; wind N.E. fresh ; rough sea. <i>Dip</i> of the magnetic needle observed at the port of Ferrol, 76° 6', centi- grade division. <i>Intensity</i> of the magnetic forces, in Gallicia, expressed by 243 oscilla- tions in ten minutes of time.
6	44 0	13 7	<i>Temperature</i> of the sea, 16°. Tem- perature of the air, 9° ; brisk gale ; the sea rough and very stormy.
7	42 7	15 24	Beyond the parallel of Cape Finis- terre, at forty-two leagues distance from this cape. Gentle gale N.N.E. air, 18° 7'. <i>Cyanometer</i> , 14°.
8	41 0	16 9	Wind north-east, very weak. Temp. of the air, 12° 5'. <i>Hygrometer</i> , 45° 6'. Deluc (82° Saus- sure).
9	39 10	16 18	<i>Temperature</i> of the sea, 15° ; temp. of the air, 14° 5' ; northerly wind, feeble ; serene sky. <i>Thermometer</i> exposed to the sun, 16° 9' ; Sun's force, 2° 4' ; in the parallel of Peniche. <i>Cyanometer</i> , 15° (the blue of the ocean measured with the same instru- ment 35°). <i>Hygrometer</i> the whole day, 81°—83° Saussure.

Days of the month.	North lat.	West long.	PHYSICAL OBSERVATIONS.
June 9	39 10,	16, 18'	<p><i>Dip</i> of the magnetic needle (latitude <math>38^{\circ} 52'</math> and longitude <math>16^{\circ} 22'</math>) <math>75^{\circ} 76^{\circ}</math>.</p> <p><i>Magnetic intensity</i>, 242 oscillations ; good observation.</p> <p>The current, which sets E. by S. and S.E., begins to be felt.</p>
10	37 26	16 32	<p>Light north-west wind, fine weather, almost in the parallel of Cape St. Vincent, and between this cape and the Azores at eighty leagues to the west of the cape.</p> <p><i>Temperature</i> of the ocean, <math>15^{\circ} 2_0</math> ; temp. of the air, <math>15^{\circ}</math> ; thermometer exposed to the Sun, <math>18^{\circ} 7^{\circ}</math> : Sun's force, <math>3^{\circ} 7^{\circ}</math>.</p> <p><i>Hygrometer</i> at noon, <math>47^{\circ}</math> Deluc (<math>83^{\circ} 5^{\circ}</math> Saussure). At three in the afternoon, <math>50_0</math> Deluc. (<math>85^{\circ} 2^{\circ}</math> Sauss.)</p> <p><i>Dip</i> of the magnetic needle, <math>75^{\circ} 35^{\circ}</math> ; oscillations 242.</p> <p><i>Cyanometer</i>, <math>14_0</math> ; blue color of the sea, nearly calm, <math>44^{\circ}</math>.</p>
11	36 4	17 5	<p><i>Temperature</i> of the sea, <math>15^{\circ} 2^{\circ}</math> ; temp. of the air, <math>18^{\circ} 6^{\circ}</math> ; weather a little cloudy. At seven in the evening, temp. of the sea, still <math>15^{\circ} 2^{\circ}</math> ; temp. of the air, <math>17^{\circ} 4</math> ; sea somewhat ruffled.</p> <p><i>Hygrometer</i>, at seven in the evening, <math>51^{\circ}</math> Deluc (<math>84^{\circ} 4^{\circ}</math> Saussure).</p>

Days of the month.	North lat.	West long	PHYSICAL OBSERVATIONS.
June 12	35° 8'	17° 15'	<p>Calm, hazy weather ; a little rain at nine in the morning ; at fifty leagues distance from the coasts of Africa, to the west of Cape Blanco.</p> <p><i>Temperature</i> of the sea, 16·2° ; temp. of the air, 20·6°. At eight in the evening, the sea 16·2° ; the air 15·7°.</p> <p><i>Hygrometer</i>, 47·8° Deluc (84° Saus- sure).</p>
13	34 30	16 55	<p>Variable weather, calm, rainy. From eleven in the morning clear sky, without clouds ; in the night, breeze from the west.</p> <p><i>Temperature</i> of the sea, 16·3° (at a depth of fifteen metres, 15·7°) ; temperature of the air, 19·7° ; thermometer exposed to the Sun, 20·3° ; Sun's force, 0·5° ; temperature of the air at eleven at night, 13·7°.</p> <p><i>Hygrometer</i>, 54·5° Deluc (87·5° Saus- sure).</p> <p><i>Cyanometer</i>, 16° ; blue color of the sea 34°. The sky has a reddish blue tint, almost violet, a singular phenomenon, which I have also sometimes observed in the Pacific Ocean, especially in the southern hemisphere, and without the sea being green.</p>



Days of the month.	North lat.	West long.	PHYSICAL OBSERVATIONS.																											
June 13	34° 30'	16° 55'	<i>Dip</i> of the magnetic needle, 73° 0', found in a dead calm. <i>Magnetic intensity</i> , 234 oscillations.																											
14	32 16	17 4	To the east of the isle of Madeira, at forty-five leagues distance; strong breeze from the west; sea very rough. <i>Temperature</i> of the sea, notwithstanding the height of the waves, 17° 7'; temperature of the air, 16° 8'. <i>Dip</i> of the magnetic needle, 71° 90', somewhat doubtful (latitude 31° 46', longitude, 17° 4'). <i>Magnetic intensity</i> , 237, very doubtful.																											
15	30 36	16 54	Fine weather, sea almost entirely calm. <i>Temperature</i> of the water, 18° 7'; temperature of the air, 20° 6'. <i>Progressive variations</i> of the hygrometer and thermometer observed carefully in the shade, and four metres above the surface of the ocean : <table><tr><td>Hours.</td><td>Saussure's hygrom.</td><td>Centigrade therm.</td></tr><tr><td>At 21½</td><td>85° 3'</td><td>21° 2' calm.</td></tr><tr><td>22½</td><td>85° 7'</td><td>20° 0' little wind.</td></tr><tr><td>23½</td><td>85° 8'</td><td>20° 0' idem.</td></tr><tr><td>0½</td><td>85° 3'</td><td>21° 4' calm.</td></tr><tr><td>2½</td><td>84° 2'</td><td>23° 7' idem.</td></tr><tr><td>3½</td><td>84° 3'</td><td>22° 5' idem.</td></tr><tr><td>6½</td><td>85° 2'</td><td>20° 0' idem.</td></tr><tr><td>7½</td><td>86° 2'</td><td>19° 8' idem.</td></tr></table>	Hours.	Saussure's hygrom.	Centigrade therm.	At 21½	85° 3'	21° 2' calm.	22½	85° 7'	20° 0' little wind.	23½	85° 8'	20° 0' idem.	0½	85° 3'	21° 4' calm.	2½	84° 2'	23° 7' idem.	3½	84° 3'	22° 5' idem.	6½	85° 2'	20° 0' idem.	7½	86° 2'	19° 8' idem.
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June 15	30° 36'	16° 54'	<p><i>Sun's force</i>, 3·1°; thermometer in the shade, 20·6°; thermometer exposed to the Sun, 23·7°.</p> <p>Between Cape Aguer and the Salvage islands, twenty-three leagues east of the latter. Pilot's reckoning, compared with the longitudes given by the marine time-keeper, indicates a current setting toward the south-east.</p>																																	
16	29 18	16 40	<p>Fine weather; westerly wind, very feeble; near the western coasts of the island of Lanzerota.</p> <p><i>Temperature</i> of the ocean, 19·3°; air, 18·0°.</p> <p><i>Cyanometer</i>, 22° (colour of the sea, 40°).</p> <p><i>Sun's force</i>, 3·6°; thermometer exposed to the Sun, 22·5°.</p> <p>Variations of the hygrometer and thermometer, the air being very little agitated.</p> <table><tr><th>Hours.</th><th>Saussure's hygrom.</th><th>Centigrade therm.</th></tr><tr><td>21½</td><td>85·3°</td><td>19·5°</td></tr><tr><td>22½</td><td>85·0</td><td>18·7</td></tr><tr><td>23½</td><td>84·8</td><td>18·7</td></tr><tr><td>0½</td><td>83·8</td><td>20·0</td></tr><tr><td>1½</td><td>83·4</td><td>21·2</td></tr><tr><td>2½</td><td>83·3</td><td>21·8</td></tr><tr><td>3½</td><td>83·5</td><td>22·5</td></tr><tr><td>4½</td><td>83·5</td><td>21·2</td></tr><tr><td>5½</td><td>83·8</td><td>21·2</td></tr><tr><td>6½</td><td>85·0</td><td>19·3</td></tr></table>	Hours.	Saussure's hygrom.	Centigrade therm.	21½	85·3°	19·5°	22½	85·0	18·7	23½	84·8	18·7	0½	83·8	20·0	1½	83·4	21·2	2½	83·3	21·8	3½	83·5	22·5	4½	83·5	21·2	5½	83·8	21·2	6½	85·0	19·3
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Days of the month.	North lat.	West long.	PHYSICAL OBSERVATIONS.
June 17	29° 21'	16° 6'	<p>Clear weather, calm at intervals : the coasts of the small island of Graciosa, and in the archipelago of islets that lie to the north of it.</p> <p><i>Temperature</i> of the Ocean, in the channel, between the islands of Alegranza and Santa Clara, where the sea is only sixty-two metres deep, 17·8°, consequently 1·5° colder than in the open sea, in the same parallel. <i>Temperature</i> of the air, 20°.</p>
18	29 3	17 10	<p><i>Temperature</i> of the sea, far beyond soundings, 18·7° ; <i>temperature</i> of the air, 18·3° : gentle breeze ; clear weather. Sun's force, 1·6° ; thermometer exposed to the Sun, 19·9°.</p>
19	28 28	18 33	<p>Arrival in the road of Santa Cruz in the island of Teneriffe.</p> <p><i>Dip</i> of the magnetic needle, 69·35°.</p> <p><i>Magnetic intensity</i>, 238 oscillations.</p> <p>Abode at the island of Teneriffe, from the 19th to the 25th of June.</p>
25	26 51	19 13	<p><i>Temperature</i> of the sea, 20° ; air, 18·8° ; strong breeze at N. E.</p>
26	25 15	20 17	<p><i>Temperature</i> of the ocean, 20° ; <i>temperature</i> of the air, 21·2°.</p> <p><i>Dip</i> of the magnetic needle, 67·60° ; very good observation (lat. 24° 53', and long. 20° 58').</p>

Days of the month.	North lat.	West long.	PHYSICAL OBSERVATIONS.
June 26	25° 15'	20° 17'	<i>Intensity</i> , 239 oscillations, computed in calm weather, to the south-west of Cape Bojador, at 62 leagues distance.
27	22 52	22 13	Sea, 20°; air, 20·1°; fresh breeze from the N. E., the Sun's force appearing only 2°. In the night, temperature of the air, 19·3°.
28	21 36	25 23	Air, 22°; brisk wind from the N. E. 90 leagues north of Cape Verd. <i>Dip</i> of the magnetic needle, 64·65°: very good observation (lat. 21° 29', and long. 25° 42'). <i>Oscillations</i> 237.
29	20 8	28 51	<i>Temperature</i> of the sea, 21·2°; air 20°. From ten in the morning to five in the evening, the thermometer did not vary 0·8°, while the breeze blew very strong. <i>Dip</i> of the magnetic needle, 63·52°. Oscillations 236 (at 60 leagues N. N. W. of the island of Santa Antonio); latitude 19° 54', longitude, 28° 45'.
30	18 53	30 41	<i>Temperature</i> of the sea, 21·8°; temperature of the air, 21·2°; fine weather. <i>Cyanometer</i> , 22·4°. <i>Hygrometer</i> , 44° Deluc (81·5° Saussure).

Days of the month.	North lat.	West long.	PHYSICAL OBSERVATIONS.																																				
July 1	17° 57'	33° 14'	Sea, 22·4°; air 24·8°. Wind N. E., moderate; cloudy weather. During the night thick fog, which lowered the thermometer at one in the morning to 21·3°.																																				
2	17 26	35 8	<p>Sea, 21·6°; air, 23°: dull weather: a few squalls. Few variations in the meteorological instruments.</p> <table> <tr> <th>Hours.</th><th>Centig. therm.</th><th>Deluc's hygrom.</th><th></th></tr> <tr> <td>1 aftern.</td><td>22·7°</td><td>51°</td><td>(86° Saus.)</td></tr> <tr> <td>2</td><td>22·9</td><td>51·2</td><td rowspan="3">} raw weather but without rain; wind N. E.; feeble.</td></tr> <tr> <td>4</td><td>23·0</td><td>51·2</td></tr> <tr> <td>5</td><td>22·9</td><td>53·2</td></tr> <tr> <td>9 evening</td><td>22·2</td><td>55·2</td><td rowspan="2">} (89° Saus.)</td></tr> <tr> <td>10</td><td>22·2</td><td>57</td></tr> </table>	Hours.	Centig. therm.	Deluc's hygrom.		1 aftern.	22·7°	51°	(86° Saus.)	2	22·9	51·2	} raw weather but without rain; wind N. E.; feeble.	4	23·0	51·2	5	22·9	53·2	9 evening	22·2	55·2	} (89° Saus.)	10	22·2	57											
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3	16 41	36 31	<p>Temperature of the sea, 22·5°. Variations of the instruments:</p> <table> <tr> <th>hrs.</th><th>ther.</th><th>Deluc's hygrom.</th><th></th></tr> <tr> <td>17</td><td>22·7°</td><td>56·8°</td><td>(88·7° Saus.) dull.</td></tr> <tr> <td>18</td><td>22·6</td><td>57·0</td><td>Sun rising, very soft rain</td></tr> <tr> <td>20</td><td>22·6</td><td>56·2</td><td>dull.</td></tr> <tr> <td>0</td><td>22·8</td><td>56·0</td><td rowspan="5">} very soft rain, scattered drops, which do not touch the hygrometer, and scarcely any way affect the hygroscopical state of the air.</td></tr> <tr> <td>1</td><td>22·8</td><td>59·0</td></tr> <tr> <td>2</td><td>23·1</td><td>52·5</td></tr> <tr> <td>3</td><td>22·7</td><td>62·0</td></tr> <tr> <td>6</td><td>21·8</td><td>60·2</td></tr> <tr> <td>11</td><td>22·7</td><td>57·0</td><td>blue, stars beautiful.</td></tr> </table>	hrs.	ther.	Deluc's hygrom.		17	22·7°	56·8°	(88·7° Saus.) dull.	18	22·6	57·0	Sun rising, very soft rain	20	22·6	56·2	dull.	0	22·8	56·0	} very soft rain, scattered drops, which do not touch the hygrometer, and scarcely any way affect the hygroscopical state of the air.	1	22·8	59·0	2	23·1	52·5	3	22·7	62·0	6	21·8	60·2	11	22·7	57·0	blue, stars beautiful.
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4	16 19	39 19	<p>Sea, 22·5°; air, 22°.</p> <p>Cyanometer, 23·5°. Sky very clear.</p> <p>At night, wind N. E. very fresh, followed by squalls, and electric rain.</p>																																				



Days of the month.	North lat.	West long.	PHYSICAL OBSERVATIONS.																								
July 4	16° 19'	39° 19'	<i>Thermometer</i> , the whole day, between 22° and 23·6° ; <i>hygrometer</i> between 87° and 89·6°, Saussure's division.																								
5	15 18	42 21	Sea, 23·0° ; air, 22·2°. Variations of the meteorological instruments : <table><tr><th>Hours.</th><th>Centigrade therm.</th><th>Deluc's hygrom.</th></tr><tr><td>At 23</td><td>21·9°</td><td>61·2°</td></tr><tr><td>0</td><td>23·2</td><td>61·5</td></tr><tr><td>2</td><td>23·4</td><td>60·0</td></tr><tr><td>3</td><td>23·4</td><td>61·2</td></tr><tr><td>6</td><td>23·1</td><td>63·0</td></tr><tr><td>12</td><td>23·3</td><td>63·4</td></tr></table> Dull and cloudy weather.	Hours.	Centigrade therm.	Deluc's hygrom.	At 23	21·9°	61·2°	0	23·2	61·5	2	23·4	60·0	3	23·4	61·2	6	23·1	63·0	12	23·3	63·4			
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6	14 57	44 40	<i>Temperature</i> of the ocean, 23·7° ; temp. of the air, 22·8°. <table><tr><th>Hrs.</th><th>Therm.</th><th>Deluc's hygrom.</th></tr><tr><td>15</td><td>22·6°</td><td>68·5°</td></tr><tr><td>18</td><td>22·7</td><td>66·5</td></tr><tr><td>20</td><td>23·3</td><td>65·5</td></tr><tr><td>22</td><td>23·1</td><td>66·4</td></tr><tr><td>0</td><td>23·5</td><td>65·0</td></tr><tr><td>7</td><td>23·6</td><td>65·2</td></tr><tr><td>12</td><td>23·5</td><td>66·0</td></tr></table> Dull and cloudy weather. Saussure's hygrometer would have remained between 92·8° and 94·4°.	Hrs.	Therm.	Deluc's hygrom.	15	22·6°	68·5°	18	22·7	66·5	20	23·3	65·5	22	23·1	66·4	0	23·5	65·0	7	23·6	65·2	12	23·5	66·0
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7	14 20	47 38	In the midst of the ocean between Africa and South America, easter-																								

Days of the month.	North lat.	West long.	PHYSICAL OBSERVATIONS.																																
July 7	14° 20'	47° 38'	<p>ly wind very brisk, sky slightly dull; sea very fine.</p> <table><tr><td></td><td>Hrs.</td><td>Therm.</td><td>Deluc's hygrom.</td></tr><tr><td></td><td>14</td><td>23·7°</td><td>64·5° (92·4° Sauss.)</td></tr><tr><td></td><td>18</td><td>22·6</td><td>62·0</td></tr><tr><td></td><td>20</td><td>23·3</td><td>61</td></tr><tr><td></td><td>0</td><td>24·4</td><td>58·5</td></tr><tr><td></td><td>4</td><td>24·2</td><td>56·0 (88·3° Sauss.)</td></tr><tr><td></td><td>8</td><td>23·8</td><td>57·2</td></tr><tr><td></td><td>11</td><td>23·6</td><td>61·0</td></tr></table> <p><i>Cyanometer</i>, at 0<sup>h</sup> 30', the sky being without vapours, 32·5°.</p> <p><i>Dip</i> of the magnetic needle, 56·30°; oscillations, 239; good observation (latitude 14° 15' and long. 48° 3').</p>		Hrs.	Therm.	Deluc's hygrom.		14	23·7°	64·5° (92·4° Sauss.)		18	22·6	62·0		20	23·3	61		0	24·4	58·5		4	24·2	56·0 (88·3° Sauss.)		8	23·8	57·2		11	23·6	61·0
	Hrs.	Therm.	Deluc's hygrom.																																
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	11	23·6	61·0																																
8	13 51	49 43	<p>Temperature of the ocean, 24·7°; temp. of the air, 23·6°.</p> <p><i>Cyanometer</i> only 17°, and yet the sky perfectly blue, without clouds or visible vapours: blue color of the ocean, 33°.</p> <p>Fine breeze, sea beautiful, at 200 leagues distance from French Guyana to the N.N.E.</p> <table><tr><td></td><td>Hrs.</td><td>Therm.</td><td>Deluc's hygrom.</td></tr><tr><td></td><td>20</td><td>23·5°</td><td>58°</td></tr><tr><td></td><td>2</td><td>23·0</td><td>57</td></tr><tr><td></td><td>4</td><td>23·0</td><td>56·2 (88·3° Sauss.)</td></tr><tr><td></td><td>7</td><td>22·8</td><td>59·0</td></tr><tr><td></td><td>12</td><td>22·3</td><td>62·2 (91·4° Sauss.)</td></tr></table>		Hrs.	Therm.	Deluc's hygrom.		20	23·5°	58°		2	23·0	57		4	23·0	56·2 (88·3° Sauss.)		7	22·8	59·0		12	22·3	62·2 (91·4° Sauss.)								
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Days of the month.	North lat.	West long.	PHYSICAL OBSERVATIONS.																											
July 9	13° 2'	52° 58'	Sea rough. Pretty strong breeze. <i>Dip</i> of the magnetic needle, 50° 67'; good. <i>Oscillations</i> , 234; a little doubtful.																											
10	12 34	54 19	Fine breeze, very clear sky. <i>Cyanometer</i> , only 16°; color of the sea, 35°. <i>Temperature</i> of the air from 17 <sup>h</sup> to 10 <sup>h</sup> between 24·6 and 23·8°. <i>Hygrometer</i> , during this time, between 88·5° and 90° Saussure.																											
11	11 17	57 47	Fine weather, light wind. <table><tr><td>Hours.</td><td>Centig. therm.</td><td>Deluc's hygrom.</td></tr><tr><td>18</td><td>24·2°</td><td>60°</td></tr><tr><td>20</td><td>24·8</td><td>59</td></tr><tr><td>21</td><td>25·2</td><td>58·3</td></tr><tr><td>23</td><td>25·0</td><td>59</td></tr><tr><td>0</td><td>25·2</td><td>58·5</td></tr><tr><td>2</td><td>26·6</td><td>57</td></tr><tr><td>8</td><td>25·0</td><td>60</td></tr><tr><td>11</td><td>23·7</td><td>58</td></tr></table> <i>Hygrometer</i> of Saussure constantly between 89° and 90·7°; on the meridian of Surinam, at 80 leagues distance from the Oroonoko and from Barbadoes; during the night a little rain and a beautiful lunar rainbow.	Hours.	Centig. therm.	Deluc's hygrom.	18	24·2°	60°	20	24·8	59	21	25·2	58·3	23	25·0	59	0	25·2	58·5	2	26·6	57	8	25·0	60	11	23·7	58
Hours.	Centig. therm.	Deluc's hygrom.																												
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11	23·7	58																												

Days of the month.	North lat.	West long.	PHYSICAL OBSERVATIONS.
July 12	10. 40'	60. 54'	<p>A smart breeze, particularly during the night ; wind east, pretty strong ; sea rough ; very fine sky, not free from vapors.</p> <p><i>Temperature</i> of the ocean, <math>25\cdot8^{\circ}</math> ; temp. of the air, <math>25\cdot3^{\circ}</math>.</p> <p><i>Cyanometer</i>, <math>14\cdot4^{\circ}</math>.</p> <p>Saussure's <i>hygrometer</i>, the whole day, from <math>89\cdot5^{\circ}</math> to <math>90^{\circ}</math>.</p> <p><i>Dip</i> of the magnetic needle, <math>46\cdot95^{\circ}</math> ; oscillations, 229 (good observation).</p>
13	11 16	62 45	<p>Cloudy, with squalls ; very strong east wind ; very high sea ; a little rain : distance one league east-south-east of the north cape of the island of Tobago.</p> <p><i>Temperature</i> of the ocean, <math>25\cdot8^{\circ}</math> ; temp. of the air, <math>25\cdot1^{\circ}</math>.</p> <p><i>Hygrometer</i>, from <math>90^{\circ}</math> to <math>91\cdot8^{\circ}</math> (Saus- sure's division).</p>
14	11 1	64 51	<p><i>Temperature</i> of the ocean, <math>25\cdot6^{\circ}</math> ; but on the shoal, which extends from the island of Tobago to that of Grenada, <math>23\cdot1^{\circ}</math> ; temp. of the air, <math>25^{\circ}</math>.</p> <p>Saussure's <i>hygrometer</i>, <math>91\cdot5^{\circ}</math> to <math>92\cdot7^{\circ}</math>.</p> <p><i>Dip</i> of the magnetic needle, <math>47\cdot5^{\circ}</math> ; oscillations, 237 ; good observation. The mountainous coast of Paria seen at 4 leagues distance : slight breeze ; fine and serene weather.</p>

Days of the month.	North lat.	West long.	PHYSICAL OBSERVATIONS.
July 15	10° 51'	66° 12'	<p>Wind north-east, feeble ; fair ; sea very fine.</p> <p><i>Temperature</i> of the ocean, on the shoal near Punta Araya, 23·4° ; open sea, 25·2° ; and at five miles distance N. N. E. of the port of Cumana the temperature of the surface of the ocean was only 22·2°, though we had no bottom at sixty fathoms depth. Is this cold owing to the current, that comes from the shoals of the island of Margareta? In very narrow seas, for instance in the Baltic, the temperature of the water changes also very suddenly. In the port of Cumana, the water of the sea kept in 1799 and 1800 constantly between 25 and 26 degrees, the temperature at low water being often 0·8° higher than at high water.</p> <p><i>Temperature</i> of the air, 28·7°.</p> <p><i>Hygrometer</i>, 86° Saussure.</p>
16	10 28	66 30	Arrived at the port of Cumana.



## DETERMINATION OF THE HEIGHTS OF SEVERAL POINTS IN THE ISLAND OF TENERIFFE.

I shall, in this dissertation, discuss the trigonometrical and barometrical measurements, made within the last century, by various travellers, who have visited the island of Teneriffe; and at the same time give an historical sketch of the attempts, which have been made to ascertain the height of the Peak of Teyde, and of the most remarkable points on the road leading to the top of this volcano. It is highly interesting, not to the science of geology alone, to know with precision the absolute height of this mountain; this knowledge is also necessary to perfect the charts of the Canary Islands, because Messrs. de Borda and Varela, at the time of the voyage of the frigate *la Boussole*, made use of the vertical angles of the Peak and the azimuths, to ascertain the relative distances of Teneriffe, Gomera, and Palma.

Although as early as the year 1648, the experiments of Pascal and Perrier had proved, that the barometer might be successfully applied to measures of height, it is however only since the beginning of the 18th century that we have accurate ideas of the elevation of a few mountains. Riccoli still gave ten Italian miles, and Nichols fifteen leagues of height to the Peak of Teyde\*. Eden did not attempt to measure the height, though he reached the summit of the volcano in 1715. His voyage † however, the earliest that was published, fixed the attention of the geographers and natural philosophers of Europe; and the first attempt at measuring the height of the Peak was made by P. Feuillée ‡ in 1724. This

\* Zach, *Journ. Astron.*, 1800, t. i, p. 396. Vieyra, *No-ticias Historicas*, t. i, p. 224.

† *Phil. Trans.*, vol. xxvii, p. 317.

‡ *Manuscript Journal of P re Feuill e*.

traveller found by trigonometrical measurement the absolute height to be 2213 toises. La Caille, speaking of this measurement in the *Memoirs of the Academy* \*, expressed his doubts of the accuracy of the result. These doubts have been revived by Bouguer; who, in fixing the limits of the perpetual snows under different zones, has examined with his usual sagacity P. Feuillée's operations; and he concludes, that the height of the Peak does not exceed 2062 toises †.

There exists also another measurement of this mountain, made during the voyage of P. Feuillée, by M. Verguin. This measurement, merely barometrical, has been hitherto neglected; because, having been calculated according to the method of Cassini, it had given the excessive height of 2624 toises ‡. This error, which exceeds two-fifths of the total height of the volcano, will be reduced to one-twentieth, if the method of Laplace, and the coefficient of Ramond, be applied to the observations of Mr. Verguin; and if we suppose, what is probable enough in a latitude so southerly, that the pressure of the air did not very sensibly change in the space of three days. On the 31st of July, 1724, P. Feuillée's barometer, at the port of Orotava, stood at 27 inches 9·7 lines. On the 3d of August the same instrument was found

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\* *Mem. de l'Académie*, 1746, p. 143. *Voy. de la Flore*, t. i, p. 114.

† *Fig. de la Terre*, p. 48. Deluc, *Rech. sur les Mod. de l'Atmosphère*, § 280 and 763. Notwithstanding the examination of Bouguer, and the well known measurement of Borda, we still find, in several physical works, the height of the Peak estimated at 2097, 2180, and 2270 toises. See the third edition of Marsden's valuable *History of Sumatra*, published in 1811, p. 14; and Breislack's *Geology*, t. i. p. 6, in which the table of heights swarms with typographical errors.

‡ *Mem. de l'Académie*, 1733, p. 45.

on Monte Verde at 23 inches, 0 lines, and at the top of the Peak at 17 inches, 5 lines. P. Feuillée mentions neither the temperature of the air at the two stations, nor the correspondent observations made at the same hours on the coast. Travellers themselves, at that time, constructed their barometers on the spot; and meteorological instruments were utterly unknown at Orotava and at Santa Cruz. The observation on the top of the volcano having been made in a season when the variation of the barometer, on the coasts of Teneriffe, seldom exceed in the space of three days one or two lines, we may, in calculating the height of the Peak, take for our basis the height of the mercury observed on the 31st of July. Supposing twenty-two centesimal degrees for the temperature of the coast several hours before the Sun passed the meridian, and five degrees for the temperature of the air at the top of the volcano, which is conformable to the law of decrement of heat in those regions; I find, by Mr. Laplace's method, two thousand and twenty-five toises, or one hundred and twenty toises more than is given by the trigonometric measurement of Mr. de Borda. Whatever alteration we make in the estimation of the temperature, and of the barometrical height at Orotava, it will still be found, and this fact is very remarkable, that the barometric measurement of Mr. Verguin is much more accurate than the geometric measurement of P. Feuillée. The error of the latter, in which the level of the ground employed for the measurement of the base was neglected, is almost three times as great as the error of the barometric measurement, which we have just stated.

The observations, which P. Feuillée made at the town of Laguna, indicate nearly the absolute height of this place, so well known for its great coolness. Taking the barometrical average of two months, during which the extreme deviations amounted only to four or five lines, we find at Laguna 25 inches, 11 lines, and at the port of Orotava 27 inches, 10 lines. Now, supposing the temperatures of these

two stations at fifteen and twenty degrees of Reaumur's thermometer, I obtain by Laplace's method, three hundred and thirteen toises for the town of Laguna. This height would be augmented only sixty-six toises, or one-fifth, if 28 inches 3 lines were taken for the mean height of the column of mercury at the port of Orotava; though it is well known, that P. Feuillée's barometer, by no means well freed from air, was constantly six or eight lines, or even more, too low\*. Mr. Lichtenstein, who has made an interesting journey into the interior of Africa, reckons the absolute height of Laguna two or three thousand feet above the level of the coasts †.

Andanson, in his voyage to Senegal ‡, states, "that the elevation of the Peak of Teyde (in 1749) was found to be more than two thousand toises." It is probable that this result was founded on a base measured by the log, and on an operation made under sail by Mr. Daprès de Manneville, commander of the vessel of which Andansen was on board.

Dr. Heberden §, in the narrative of his excursion to the top of the Peak in 1752, says he found the absolute elevation of the volcano to be 15396 English feet, or 2408 toises. "This result," adds he, "has been confirmed by two other operations, which I have successively executed: it is also entirely conformable to the results of two trigonometrical operations made long before by Mr. John Cross, English Consul at Santa Cruz in Teneriffe." Here are five measure-

\* Feuillée's barometer at the top of the Peak, 17 inches 5 lines. Borda's barometer at the same point, 18 inches 0 lines. Lamanon's barometer, 18 inches 4 lines.

† Allgem. Geog. Ephemer. 1806, p. 51.

‡ Vol. i, p. 8.

§ Phil. Trans. vol. xlvii, p. 353. Cook's second Voyage round the World, vol. ii, p. 282. Barrow, Voyage à la Cochinchine, t. 1, p. 69.



ments, which it is stated, agree perfectly well with each other, and in which there is an error of more than five hundred toises, or a fourth part of the total height of the Peak. Dr Heberden lived seven years at Orotava; we must regret, that he enters into no detail on the nature of the instruments employed by him and Mr. Cross, or the values of the angles, or the length and levelling of the base, on which the triangles repose. The whole of these operations, which we have just mentioned, deserve no more credit than those of Don Manuel Hernandez \*; who asserts, that he found in 1742, by geometrical measurement, the height of the volcano to be 2658 toises, and consequently 200 toises higher than Mount Blanc.

We are indebted to Borda for the knowledge of the real elevation of the volcano of Teneriffe. This excellent geometrician obtained an exact result after having fallen into an error, which he attributes to the negligence of one of his coadjutors. He took three measurements of the Peak; two geometrical, and one barometrical. The first geometrical measurement †, executed in 1771, gave only 1742 toises; and as long as it was considered as accurate, Borda and Pingré found, by operations made under sail, the height of the Peak 1701 toises ‡. Happily, Borda visited the Canary Islands a second time, in 1776, conjointly with Mr. de Chastenot de Puységur; and he then executed a more accurate trigonometrical measurement, of which he published the result only in his Supplement to the Voyage of the Flora §. We there find “that the principal cause of the error committed in 1771 had been a mistake in the indication of an

\* Borda, Voyage de la Flore, t. i, p. 88.

† Ibid, t. i, p. 89.

‡ “All the parts of our work reciprocally confirmed each other, and concurred in the same determination.” Ibid. t. i, p. 120. Journ. de Phys, 1776, p. 66; and 1779, p. 129.

§ Vol. i, p. 378.



angle, minuted in the register as being thirty-three minutes, while it was in reality found to be fifty-three minutes."

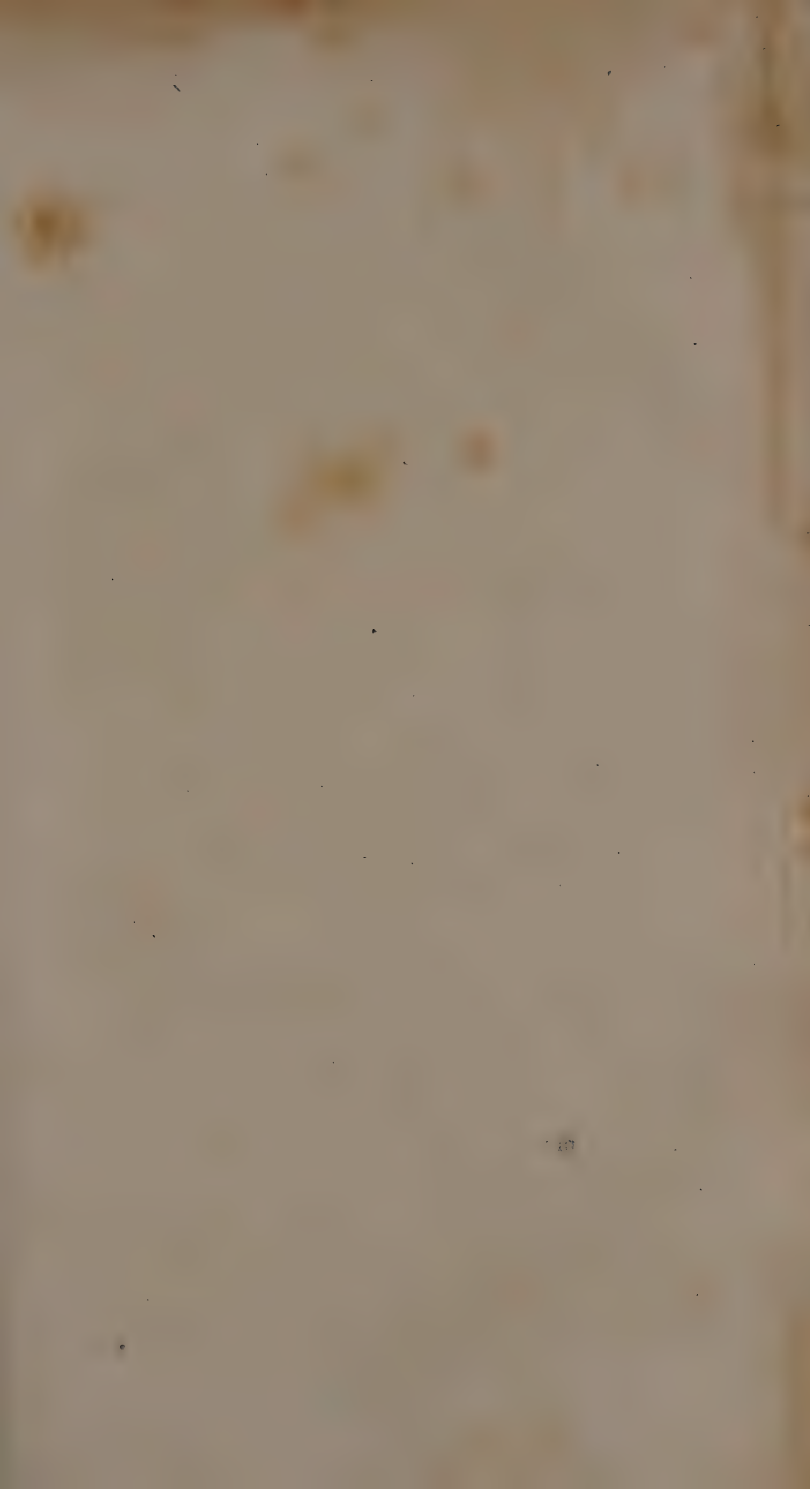
The result of the trigonometrical measurement made in 1776 is 1905 toises; it is this which is now most generally adopted, and on which is in great part founded the position of the Canary Islands, in Varela and de Borda's charts. I trust, that I shall render a service to naturalists, philosophers, and navigators, in here recording the detail of the operations made during the voyage of the frigate la Boussole, and taken from the valuable manuscript which I mentioned in the preceding chapter \*. It were to be wished, that Mr. de Borda's Journal was published entire. The results it contains are found in the *Carte particulière des Isles Canaries, d'après les Observations de la Boussole et de l'Espiègle, 1776*. This chart, the best of all that have hitherto appeared, forms a part of the collection published by the Dépôt of the Marine, at Paris.

"The measurement of the Peak of Teneriffe," says Mr. de Borda, "was not an object of mere curiosity, but was essentially connected with our nautical labors. It was necessary for us to know the exact height of this volcano, in order to avail ourselves of the observations of apparent height which we had made at several points of the island of Teneriffe, Gomera †, and Canary, and which were to serve for ascertaining the longitudes and latitudes of those points.

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\* Vol. i, p. 142. The manuscript of the Dépôt is 190 pages in 4to; it was copied from the original, by Mr. de Fleurieu. I am indebted for the communication of it to the kindness of Vice-admiral Rosily.

† At the port of Gomera, for instance, Mr. de Borda found the angle of altitude of the Peak  $4^{\circ} 1'$ . An azimuth placed the mountain east  $24^{\circ} 17'$  north. Supposing it's elevation above the level of the ocean 1904 toises, we find the port of Gomera distant from the Peak  $0^{\circ} 27' 18''$ .



*M. Franqui's Garden*

*d*

*La Par*

*ai*

*Spot where Father Pauline measured his base*

*La Montañita del Puerto*

*Peak of Teneriffe*

Fig. 1.

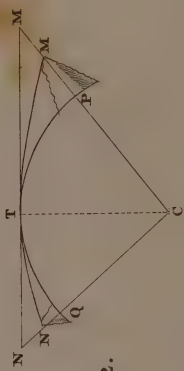


Fig. 2.

The ground in the neighbourhood of the port of Orotava being unequal, and intersected with vales, it was not possible for us to find a base extensive enough to determine the distance of the Peak by a single triangle, and we employed three. We measured near La Paz, a country house of Mr. Cologan, our first basis \*,  $a b$ , of 229.5 toises; by means of this we calculated a second,  $a c$ , of 614 toises; and afterward a third,  $c d$ , of 1526 toises. The point  $c$  was the summit of the hill, called by the natives the *Montanne del Puerto*, which commands the town of Orotava. The station  $d$  is the western extremity of a gallery of the house of Colonel Franqui, at the villa del Orotava, near the dragon-tree so celebrated for it's size and age. It appears that the base of P. Feuillée had been measured on a plain sufficiently large, but not horizontal, at the foot of the hill of La Paz, near Mr. Cologan's country house. Our base  $a b$  was measured successively by two different parties: the first found it 1377 feet 6 inches, the second 1377 feet, 3 inches, 6 lines. Both made use of three rods of fifteen feet each, carefully measured by a three foot rule, which Mr. Varela had compared at Cadiz with the Peruvian toise of Mr. Goden. The following were the angles taken with a quadrant of a foot radius, made by Ramsden.

Triangle $a b c$ .	Triangle $a c d$ .	Triangle $c P d$ .
$b a c = 85^{\circ} 53' 55''$	$d a c = 85^{\circ} 58' 40''$	$c d P = 94^{\circ} 0' 40''$
$a b c = 73 \quad 8 \quad 55$	$d c a = 70 \quad 20 \quad 55$	$d c P = 76 \quad 34 \quad 0$
$b c a = 20 \quad 57 \quad 15$	$a d c = 23 \quad 40 \quad 8$	
<hr/>	<hr/>	
180   0   5	179 59 43	

" We measured the three angles of the triangles  $a b c$  and  $a c d$ . As in the triangle  $c P d$  this kind of verification could

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\* See Plate 1.

not be employed, I measured with the greatest exactness the two angles  $cdP$ , and  $dcP$ , by means of a reflecting circle; and I found only from 8 to 10 seconds of difference. Hence it follows, that the angle at the Peak,  $dPc$  is  $9^{\circ} 25' 20''$ . We find also  $ac = 3686.2$  feet;  $ad = 8647.3$  feet;  $cd = 9159.5$  feet;  $cP = 55814.6$  feet; and  $dP = 54420.9$  feet. The vertical angles give the following heights of the Peak, or of the different stations from one another. Altitude of the Peak seen from point  $d$ ,  $= 10423.2$  feet; the same seen from the point  $c$ ,  $= 11116$  feet; that of the point  $d$  above the point  $a$ ,  $= 733.6$  feet; the same above the point  $c = 687.6$  feet; and that of the point  $c$  above the point  $a = 47.3$  feet. From these data, the height of the Peak above the point  $d$

being	-	-	-	-	-	Feet.	10423.2
if we add the height of the point $d$ above the point $a$	733.6						
we have a first height of the Peak above the point $a$	11156.8						
In the same manner, that of the Peak above the							
point $c$ being	-	-	-	-	-		11116.0
If we add that of the point $c$ above the point $a$	47.3						
we have a second height of the Peak above the							
point $a$	-	-	-	-	-		11163.2

“Taking the mean of these two results, we find 11160 feet; and on deducting for the effect of the refraction 13.7 feet, we have 11146.3 feet. It now remains to determine the height of the point  $a$  above the level of the Ocean. The depression of the horizon of the sea, at  $a$ , was  $17' 77''$ , and at  $d$ ,  $32' 25''$ . According to these depressions, the point  $a$  is raised above the level of the Ocean 283.6 feet; and on adding this quantity to the height of the Peak\* above the

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\* Mr. de Borda had found, on his first calculation, 1904 toises, assuming nineteen feet for the effect of the refraction. He has not indicated the apparent altitudes; but we may deduce them from the values of  $dP$  and  $cP$ . At  $c$  the Peak



point *a*, we have 11430 feet absolute height, or 1905 toises."

The third measurement made by Mr. de Borda was a barometrical one. We have extracted the following details also from the Manuscript of the Dépôt, and find them nearly agreeing with the results published by Mr. Cavanilles in 1799, from the Manuscript of Don Jose Varela in the *Anales de Ciencias naturales* \*. "Mr. de Borda left Santa Cruz the 27th of September 1776. He was accompanied by forty persons, among whom were eleven officers of the French and Spanish navy. They were provided with variation compasses and dipping needles, a time-keeper, several thermometers, and two excellent barometers, which had been compared, at the port of Orotava, with the barometer of Mr. Pasley, a Scotch merchant†. On their return from the Peak, these instruments were verified anew; the difference remained absolutely the same, and by the interpolation of a great number of observations made hourly by Mr. Pasley, the following differences were found :

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must have subtended a vertical angle of  $11^{\circ} 29' 18''$ . A slight error appears in the altitudes of *d* above *c*, and of *c* above *a*. At the port of Orotava, at the house of Mr. Cologan, the apparent altitude of the volcano was found to be  $11^{\circ} 29' 35''$ . An azimuth gave for the position South  $29^{\circ} 44'$  west, whence results a distance of  $0^{\circ} 9' 45''$ .

\* T. i, p. 295. I know not from what misunderstanding it is asserted, in this same work (t. i, p. 85), that I had found the height of the Peak 1917 toises.

† Mr. Pasley declared, that he had not observed, for several years, Reaumur's thermometer at the port of Orotava, above  $22^{\circ} 7'$ , or below  $12^{\circ} 5'$ .

Stations.	Barometers.			Ther. in the air. Scale of Reaum.	Remarks.
	inches. lines.	inches. lines.	lines.		
Pino del Dornajito Port of Orotava	25 23	1·2 2·8		16° 20	
Station of the Rocks Port - -	19 28	9·5 2·7	9·8 3·0	8 19·5	Eight in the evening.
Cavern of Ice Port - -	18 28	9·2 2·8		10 19	Twenty minutes after seven in the morning.
Foot of the Piton Port - -	18 28	4·5 2·8		9 19·5	Half after eight in the morning.
Summit of the Peak Port - -	18 28	0·0 2·8	18 28	8·5 20·0	Half after ten in the morning.

" From eight in the evening of the 30th of September, to half after ten in the morning, of the first of October, the barometer had varied only 0·2 of a line. According to the barometric method of Deluc \*, we find the following heights, adding 11 toises for the elevation of Mr. Pasley's house above the level of the sea : Pino del Dornajito, 516 toises ; Station of the Rocks, 1518 toises ; Cavern of Ice, 1757 toises ; foot of the Piton, 1847 toises ; Summit of the Peak, 1929 toises."

I have recalculated Mr. de Borda's observations, conjointly with Mr. Matthieu, after the method of Mr. Laplace ; and, supposing the temperature of mercury equal to that of the air, and reducing the station to the level of the sea, we obtained for the Pino del Dornajito 533 toises ; for the Estancia de los Ingleses, 1555 toises ; for the Cavern of Ice, 1799 toises ; for the Foot of the Piton, 1892 toises ; for the Top of the Volcano, 1976 toises. This last result differs from that of the trigonometrical measurement twice as much as the height obtained by the formula of Deluc. We shall discuss farther on the causes of error that may have affected the particular operations.

It commonly happens, when the application of small corrections to barometrical and thermometrical heights is in question, that travellers, who have made observations together, do not fix on the same numbers, as means of good observations.

Messrs. Varela and Arguedas give, in their memoir on the measurement of the Peak, the following barometrical heights :

	inch.	lin.	
1. Pino del Donajito	25	0·86	Th. 17° R.
Level of the Sea	28	4·00	19 $\frac{1}{6}$

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\* Compare Fleurieu in Marchand's Voyage, t. ii, p. 11. Forster (Observat. during a Voy. round the World, vol. i, p. 22) allows the Peak 12340 english feet, or 1931 toises, from Borda's barometrical measurement.

		inch.	lin.	
2. Estacion de los Ingleses	-	19	9·81	Th. 9°
Level of the Sea	-	28	3·72	19 $\frac{1}{2}$
3. Cueva de la Nieva	-	18	8·93	11 $\frac{1}{8}$
Level of the Sea	-	28	3·51	18 $\frac{1}{3}$
4. Foot of the Sugar Loaf	-	18	3·89	9 $\frac{1}{2}$
Level of the Sea	-	28	3·51	19 $\frac{1}{20}$
5. Top of the Peak	-	18	0·11	8 $\frac{1}{2}$
Level of the Sea	-	28	3·72	19 $\frac{1}{10}$

Mr. Varela finds, I know not after what formula, 534 toises for the first station, 1531 toises for the second station, 1780 toises for the third station, 1864 toises for the fourth station, and 1940 for the fifth station. The small differences which may be observed between the barometrical heights indicated by the Spanish navigators, and those laid down by Mr. de Borda, arise in a great measure from the one being reduced to the level of the sea, while the others refer to the height of the ground where stands Mr. Pasley's house.

At the time of La Pérouse's Voyage in 1785, Mr. Lamanon carried a barometer to the top of the Peak of Teneriffe. The observation of this naturalist\*, calculated by Mr. Von Zach, gives, by Mr. Deluc's method, 1856 toises; by that of Sir G. Shuckburgh, 1893 toises, and by that of Roy, 1889 toises. The result of the same barometric observation, according to Mr. Laplace's formula, is 1902 toises.

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\* See vol. i, p. 188. Zach. Journ. Astron., 1800, p. 396. We are surprised to see, that, at a time when the useful labours of Deluc, Shuckburgh, and Tremblay, on the barometric formulas, had long been known, the editor of La

Mr. Johnstone, measuring a base by means of the log, found the height of the Peak to be 2023 toises\*. Mr. de Churruca in a voyage to the Straits of Magellan, made in 1788, attempted also to determine the height of the volcano, by a geometrical operation while under sail †. He found it 2193 toises, “congratulating himself on having attained a greater exactness than could reasonably have been expected (*toda esperanza racional*), since the barometrical heights calculated by Bezout ‡ gave the same number of toises.” It is the same with the measurement of mountains, as with the determinations of latitudes and longitudes. The observers are satisfied with their operations, when they find them agree with some old results, to which they give the preference above all others.

Mr. Cordier measured the Peak on the 16th of April, 1803, employing Mossy's barometer, which he had boiled the preceding evening, and in very fine and settled weather, which lasted a month. “The instruments were placed to the windward of the Peak, and the barometric height was brought to the temperature of the ambient air. The correspondent barometer, of English construction, differed only  $\frac{7}{10}$  of a line, ancient French measure, from that of Mossy employed by the traveller. Though the persons appointed to make the observations at Orotava, Messrs. Little and Legros, did not employ the nonius, they estimated nevertheless the heights of the mercury with great exactness to fourths or fifths of a line §.” Mr. Cordier took account

Pérouse's voyage (t. ii, p. 18) should have expressed so many doubts of the results obtained by the barometer.

\* Lord Macartney's Voyage, t. 1. p. 158.

† Viage al Magellanes, Apendice, p. 10.

‡ Cours de Mathematiques, vol. iv, p. 416 (edit. de 1775).

§ These particulars and barometrical heights, which were not printed in the Journal de Physique, t. lvii, p. 60, have



of the small changes of level in the cistern ; and being well accustomed to barometric measurements, employed every necessary precaution, to obtain an accurate result. The following is the table of his observations.

TABLE.

Stations.	Hours.	Barometer.		Reaum. Therm.
		inch.	lines.	
Estancia de los Ingleses Port of Orotava	4½	19	9·5	4·9°
		28	4·6	15·0
Summit of the Peak Port of Orotava	the morning	18	4·0	6·7
		28	5·6	19·9

The corresponding barometer was placed at the height of seven toises above the level of the sea. Mr. Cordier found by Deluc's formula the Station of the Rocks to be 1529 toises, and the top of the volcano 1901 toises. Mr. Laplace's formula gave me for the first of these points 1550 toises ; and 1920 toises\* for the second.

been communicated to me by Mr. Cordier. This traveller, who has visited Egypt, Spain, and the Canary Islands, is preparing an interesting work on extinct volcanoes.

\* In the manuscript voyage of Mr. O'Donnell, for the communication of which I am indebted to the kindness of Mr. Leudé de Segrai, is the following note : " The barometric measurements which we made of the height of the volcano nearly coincide (*con corta diferencia*) with those of Mr. Cordier, paying attention to the difference between the French and Spanish toises, absolute height of the ravines at the foot of the Peak 1278 Spanish toises ; Estancia de los

Let us now resume the barometrical and geometrical measurements of the Peak made for a century past.

### 1. Geometrical measurements.

#### a) made on land.

	toises
P. Feuillée, in 1724	2213
the same result modified by Bouguer	2062
Heberden and Cross, five operations, in 1752	2408
Hernandez, in 1742	2658
Borda and Pingré, in 1771	1742
Borda, in 1776	1905

#### b) made under sail.

Manneville, in 1749	2000
Borda and Pingré, in 1771	1701
Churruca, in 1788	2193
Johnstone,	2023

### 2. Barometric measurements calculated after the formula of La Place.

	toises
Feuillée and Verguin, in 1724	2025
Borda, in 1776	1976
Lamanon, in 1785	1902
Cordier, in 1803	1920

These measures, taken at different periods, vary from 1700 to 2600 toises; and, what is remarkable enough, the results obtained by geometrical operations differ more from each

Ingleses, 1731 toises; summit of the Peak, 3287 toises." I cannot guess what Mr. O'Donnell calls Spanish toises; for supposing him to mean the *vara castellana*, 2·23 of which make a French toise, the volcano would be much less elevated than Mr. de Borda found it, even in the first of his three measurements.

other, than those which were found by the barometer. It has nevertheless been extremely wrong to cite this want of harmony as a proof of the uncertainty of all measurements of mountains. Angles, the value of which is determined by imperfect graphometers ; bases that have not been levelled, or the length of which has been determined by the log ; triangles that give an excessively acute angle at the summit of the mountain ; heights of the barometer without any notice taken of the temperature of the air and of the mercury ; unquestionably are not means calculated to lead to accurate results. Of fourteen trigonometrical and barometrical operations above indicated, the four following only can be considered as true measurements.

	toises.
Borda by trigonometry	1905
Borda by means of the barometer	1976
Lamanon, the same	1902
Cordier, the same	1920

The average of these four observations, the whole of the particulars of which are known to us, makes the absolute height of the Volcano 1926 toises ; but we must here discuss the question, whether, in taking the mean, we ought to exclude Borda's barometric measurement, as erring too much in excess ; or whether we ought not prefer the result of the trigonometrical to that of the barometric measurements of a peak almost continually swept by ascending or descending winds.

The trigonometrical operation, made in 1776, is more complicated than those generally are, by which we determine the elevation of a single point. Travellers are in the practice of employing either a base directed toward the summit of a mountain, and two vertical angles taken at the extremity of this base, or rather a base nearly perpendicular to the former, two angles of position taken in an oblique plane, and a single vertical angle. In both cases a direct measure is taken of a side of the triangle, the summit of which is at the top of the mountain. The measurement of the Peak ex-

cuted by Mr. de Borda was a trigonometrical operation precisely similar to those, by which, in the measurement of a meridian, the heights of signals, or of mountains near those signals, above the level of the sea, is determined. It cannot be denied, that the simplicity of a method, and the small number of the elements entering into the calculation of the altitude, offer peculiar advantages ; but it would be unjust to condemn more complicated operations, if we could be assured, that the observers had taken the greatest care in the resolution of each triangle.

Mr. de Borda could not directly measure the great base of 1526 toises, at the extremities of which he determined the oblique angles of position, and the vertical angles that subtend the height of the volcano. The length of this base was found by the resolution of two small triangles ; and this determination deserves so much the more confidence, as all the angles were directly measured, as the result obtained by a small quadrant of Ramsden was verified by a reflecting circle, as the errors of each angle do not appear to have exceeded eight or ten seconds, and as the first base of 213 toises was measured twice, without finding more than two inches and a half difference. I do not believe, that this part of Mr. de Borda's measurement can have been deficient in accuracy ; and it must be hoped, that the same precision was attained in the vertical angles, three of which were indispensable for the measure of the Peak ; namely the summit of the Piton seen at *d*, the signal *d* seen at *a*, and the depression of the horizon of the sea. It might have been wished, that the observer had determined these angles by means of his reflecting circle, employing as an artificial horizon a plane glass, or mercury\* ; for the error of the line of collimation and the horizontal position of the instrument

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\* I have shown in another place, that, on the seashore, we can measure with great exactness the depression of the horizon with a reflecting instrument, by taking alternately

are very difficult to determine with exactness in a moveable quadrant of a foot radius. According to the manuscript kept in the *Depôt de la Marine*, this verification of the vertical angles did not take place; and the accordance of the two altitudes of the Piton above the points *d* and *e* is a proof rather of the constancy of the error of collimation, than of the precision of the absolute value of the angles. In order to have obtained two comparative results, Mr. de Borda should have taken seven zenith distances; that of the summit seen at *c* and at *d*, that of the signal *d* seen at *a* and at *e*, that of the signal *c* seen at *a*, and the depressions of the horizon of the sea measured at *d* and at *a*. It is well known, that these zenith distances are more difficult to obtain with exactness than the oblique angles of position, especially when we cannot make use of an astronomical circle of repetition. Farther, in similar circumstances, a method is so much the more disadvantageous, as the vertical angles are more numerous. To solve the question, what is the number of toises by which the height of the Peak may have been found too great, or too little, I have supposed an error in the measure of the base, in that of the vertical angle subtended by the mountain, and in the terrestrial refractions. If the volcano be 1925 toises of absolute height, instead of 1905 toises, the angle of *P* at *c* would be, according to Mr. Oltmann's calculation and mine,  $10^{\circ} 36' 34''$ , instead of  $11^{\circ} 29' 18''$ , found by Mr. de Borda; the bases *c d* and *a b*, would be 9258 and 1392 feet, instead of 9159 and 1278. But how can it be supposed, that he was deceived  $7' 16''$  in determining the error of collimation of the quadrant, and fourteen feet in the double measurement of a base of 229.5 toises? We are ignorant at how much Mr. de Borda estimated the effect of the terres-

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the height of the Sun above the horizon of the sea, and in an artificial horizon, and reducing these heights to the same instant.



trial refraction ; but it is probable, that this supposition did not much differ from one-tenth of the arc. The distance of the volcano is nine miles, and a variation of refraction of 22'' would change the total height of the mountain but one toise.

As bases adapted to the measurement of mountains are not generally to be found on a coast, and at the level of the Ocean, travellers are forced to recur, either to barometrical measurements, or to the depression of the horizon. In Mr. de Borda's operation, these reductions have been pretty considerable, *d* being elevated 169 toises, and *c* 55 toises above the surface of the sea. But when the subject of discussion is the comparing barometrical and geometrical measurements, which differ but a small number of toises, we must examine, what is the limit of the mistakes that may be committed, and whether the measure be too great or too little. The variations of the terrestrial refraction elevate or depress the horizon of the sea two or three minutes, to an observer placed on the coast three or four toises high. At this distance the trajectories may be more or less concave or convex, according to the temperature of the land and of the sea, and the unequal decrement of density in the successive strata of the air. In proportion as the observer increases his height above the coast, the mistakes owing to the irregular variation of the refractions diminish considerably ; and it is easy to show, that at the time of Mr. de Borda's operation they did not exceed three or four toises\*. As the sea at this period was colder than the air, the stations *c* and *d* may have been found

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\* The numerous observations of depression made by Mr. Méchain at Montjoux, near Barcelona, differ from each other but  $7\frac{1}{4}$  toises, the total height of the mountain being 105 toises. Delambre, *Base du Système métrique*, t. ii, p. 759 and 765.

lower than they really are\* ; and we may suppose, what is confirmed by barometrical measurement, that the trigonometrical result obtained in 1776 is rather too small than too great.

On resuming what has just been laid down from examining in succession the different elements, that enter into the calculation of the absolute elevation of the Peak of Teneriffe, it follows, that the trigonometrical measurement made by Mr. de Borda is probably exact at least to a three hundred and sixteenth of the total height; unless we suppose accidental mistakes, owing to the negligence of the observers.

I have no doubt but the same degree of exactness may be obtained in very favorable circumstances from repeated measurements made by the barometer ; but it is difficult to judge, amidst a few isolated observations, whether oblique winds, or an unequal distribution of heat in the successive strata of the air, have not altered the results. Of three barometric measurements made by Messrs. de Borda, Lamanon and Cordier, and calculated after the formula of Laplace, and the

\* Biot, on extraordinary refractions, in the *Mem. de l'Institut*, 1809, p. 157, 177, and 180. Mr. de Borda, like the greater part of those geometricians who have measured the depression of the horizon, has neglected to indicate the temperature of the ocean : but we know that at this period the air was at 25 degrees, and from the observations already made, page 66—80, we may admit, that the heat of the water of the sea was from 20 to 21 degrees. Now, heights of thirty toises, calculated on the supposition of a mean refraction of 0.08, and of a uniform decrement in arithmetical progression, appear diminished three toises when there are four degrees of difference between the temperature of the air and the water. This number is deduced from the numerous observations made by Messrs. Biot and Mathieu at Dunkirk.

coefficient of Ramond, there is only the second which does not give a greater height than the geometrical operations. If Deluc's or Tremblay's formula be substituted for that of Laplace, the heights, instead of being too great, will be too little. Supposing the Peak to be really 1905 toises high, Laplace's formula, applied to Messrs. Lamanon and Cordier's observations, would be erroneous only  $5\frac{1}{2}$  toises, or a three hundred and forty sixth; an extremely small quantity, and which would be the half or the third only of that, to which excellent observers may be often exposed\*.

The first coefficient† of the barometric formula of Mr. de Laplace, published in 1798, was founded on the comparison of the barometrical and geometrical measurement of the volcano of Teneriffe, made by Mr. de Borda. The illustrious author of *La Mécanique céleste* having afterward found, that this coefficient did not give exact heights, substituted another, furnished by the excellent observations of Mr. Ramond. On examining the manuscript narrative of Borda's voyage, we cannot guess at the source of an error, which seems considerably to surpass that of the barometric measurement of Mount Blanc by Saussure. The correspondent barometer was ob-

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\* Mr. d'Aubuisson concluded, after having discussed a great number of observations calculated after the formula of Laplace, and compared with exact geodesical measures, "that in avoiding the manifest causes of inexactness, such as the morning hours, the considerable changes of weather from one day to another, storms, and the influence of localities, we may consider a hundredth as the limit of the mistakes." He adds, that "most commonly, by fortunate compensations, the error will be only some thousandths." *Journal de Physique*, t. lxxi, p. 35.

† The coefficient, 17972 metres. *Exposition du Système du Monde*, ed. 1, p. 82. Ramond, *Mém. sur la Formule barométrique*, p. 2.

served at Orotava every quarter of an hour; its greatest variations, in twenty-four hours, were a few tenths of a line. The scales were carefully verified; and an account was taken of the accumulation of the mercury in the cistern\*. The thermometer was observed in the shade; the slightest circumstances are found indicated in Messrs. de Borda and Varela's journals. They are the only travellers, who have carried two barometers to the top of the Peak. Both instruments agreed within three or four tenths of a line with each other, and the average of both was constantly taken. If we were not acquainted with the real height of the Peak to a considerable degree of exactness, we might presume, that the barometric measurement taken in 1776 could not be a hundredth erroneous, while it is probably beyond a fiftieth. It is sufficient to compare the indications of Borda's barometer and thermometer with the indications of these same instruments in Lamanon and Cordier's voyages, to discover, that in the morning of the 1st of October, 1776, on the summit of the Piton, the pressure of the air underwent an extraordinary and very problematic modification. The following are the elements of this comparison.

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\* It was 0.9 of a line on the brink of the crater.





We are struck at seeing in this table, that Mr. de Borda found his barometer, at the summit of the Peak, four lines lower than other observers; and this, without any indications of the thermometer tending to explain why there was so enormous a difference in the atmospherical pressure\*. It might be supposed, that the instruments were deranged during the night, which the travellers passed at the Station of the Rocks; but we find it expressly noted in Messrs. de Borda and Varela's journals, that, the day after the excursion, the difference between Mr. Pasley's barometer at Orotava, and those which had been made use of for the measurement of the Piton, remained the same to nearly two tenths of a line. The volcano of Teneriffe, like all other very slender peaks, is undoubtedly but little adapted to disclose the error of a barometric coefficient. Oblique winds sweep along the rapid declivity of the mountain; and it is to be presumed, that, at the time when Mr. de Borda measured it, a very violent ascending wind, or some other unknown deranging cause, occasioned the barometer to fall. The weather had been rainy the preceding evening; the decrement of caloric was very slow and probably of very little uniformity; circumstances under which any formula would be at default; but notwithstanding these considerations, without the testimony of an observer so exact as Mr. de Borda, we should scarcely believe that the barometric pressure could change four lines at a height of more than 1900 toises, and at the limits of the torrid zone. A single barometric measure-

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\* The error of a degree in the indication of the temperature of the air would alter the height of the Peak only 3·8 toises nearly. A considerable number of good observations, made at the top of St. Bernard, prove, that the whole of the calculated elevations are too great or too little, every time that the temperatures are above or below the mean temperature of the two stations. Journ. de Phys. t. lxxi, p. 10.

ment is like a longitude determined by the mere difference of time : both, executed with good instruments, and under favorable circumstances, are susceptible of great exactness ; but when the meteorological variations, or the rate of the chronometer, are not regular and uniform, it is impossible to fix the limit of the errors, as we may do with success in discussing a geometrical operation, or the result of a series of lunar distances.

After having excluded the barometric measurement of Borda, two others remain, which inspire great confidence, but of which one appears to be somewhat too little, and the other too great. We have already remarked, that their mean result does not differ 0.003 from the geometrical measurement ; and we shall not give a preference to the barometric observations of Lamanon over those of Mr. Cordier, because we think we have proved, that the result even of the trigonometrical measurement may well be a few toises too small, and Mr. Cordier made his excursion in very fine and settled weather. This gentleman thinks, that his measurement must have given a result near the truth, on account of the numberless precautions which he took to avoid errors \*. The observation was made in the morning ; and it is known, that at this time of the day Laplace's formula makes the heights too little, because his coefficient was deduced from observations made at noon ; but on the other hand, Mr. Ramond has rendered it probable, that the coefficient appropriate for our northern countries must undergo a slight diminution to adapt it to the measurement of the heights comprised between the tropics, or near the limits of the torrid zone †. A compensation therefore took place : and this compensation was not disturbed by the effects of the diurnal variation of the barometer. I insist on this latter circum-

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\* Ramond, p. 5 and 26.

† Ibid, p. 97.

stance, because distinguished natural philosophers have recently asserted, that the barometer must sink on high mountains, while at nine in the morning it reaches its maximum in the plains. This assertion\* is founded only on theoretical views, and on a local phenomenon observed by Saussure in the Alps. The observations made by Mr. Bonpland and myself on the horary variations of the barometer, from the coasts to two thousand toises height, prove on the contrary, that, under the tropics, the mercury reaches it's maximum and it's minimum exactly at the same hours in the low regions and on the summits of the Andes.

The real height of the Peak of Teneriffe differs little probably from the mean between the three geometrical and barometrical measurements of Borda, Lamanon, and Cordier.

1905 toises

1902

1920

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1909

The exact determination of this point is of importance to the science of physics, on account of the application of the new barometric formulas ; to navigation, on account of the angles of altitude, which experienced seamen sometimes take, when they pass in sight of the Peak ; and to geography, on account of the use which Messrs. Borda and Varela have made of the same angles, in the construction of the chart of the archipelago of the Canaries.



In the second chapter of this work, vol. i, p. 186, we have entered into the question, whether the coast of Africa could be seen from the summit of the Peak of Teneriffe. This problem has been discussed by Mr. Delambre, to whom we are indebted for so great a number of valuable observa-

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\* Journ. de Phys. t. lxxi, p. 15.

tions on horizontal refractions. The following are the foundations of the calculations, of which we have given only the result, in that chapter. Let  $m$  (fig. 2) be the Peak of Teneriffe, and  $N$  the coast, the distance of which from the foot of the Peak is the arc  $P T Q = 2^{\circ} 49' 0''$ . As refraction makes objects appear higher than they really are, it will be possible to see from the top of the Peak the point  $N$ , although it is concealed by the curve of the Earth. This point will be really visible if it be elevated enough to send forth a ray, which, in describing the curve  $N T M$  across the strata of the atmosphere, only skims the Earth in  $T$ . From the summit of the Peak we should perceive then at once the points  $T$  and  $N$ , and an observer placed in  $T$  would see the points  $M$  and  $N$  in his horizon  $N' T M'$ . If we designate by  $h = 1904$  toises, the height of the Peak, according to the geometrical measurement of Borda; by  $R = 3271225$  toises, the radius of the Earth; and finally by  $c$  the coefficient of the terrestrial refraction, the mean value of which was found to be  $0.08$  by Mr. Delambre; we shall have the distance  $P T$ , at which the observer ought to be in order to see the summit  $M$ , at  $M'$  in the horizon, by the formula,

$$\text{tang. } P T = \frac{1}{(1-c)} \sqrt{\frac{2h}{R}}$$

which gives  $P T = 2^{\circ} 7' 26''$ . Such is the greatest distance at which we can perceive the Peak from the level of the sea. If we deduct  $P T$  from  $P T Q = 2^{\circ} 49' 0''$ , there will remain  $Q T = 4' 34''$ ; and with this distance we shall easily find the height  $N Q = h'$ , which the coast must have to appear at  $N'$  at the horizon. In fact, if in the preceding formula we substitute  $Q T$  for the arc  $P T$ , and  $h'$  for the height  $h$ , we shall have

$$\text{tang. } Q T = \frac{1}{(1-c)} \sqrt{\frac{2h'}{R}};$$

whence we deduce

$$h' = \frac{R (1-c)^2 \text{tang.}^2 Q T}{2} = 202.2 \text{ toises.}$$

Thus by means of the refraction, and notwithstanding the curve of the Earth, which at the distance PQ would conceal a mountain of 370 toises, we might sometimes see a mountain situate on the coast only 202 toises high; but as the refractions are uncertain, and may even be negative, it would be imprudent to affirm any thing for such great distances, for which we have no observation.

#### Results of the determinations of height.

	toises.
Town of Laguna	360
----- Orotava	163
Pino del Dornajito	533
Estancia de los Ingleses	1552
Cavern of Ice	1732
Foot of the Piton	1825
Summit of the Peak of Teneriffe	1909



I have given in the third chapter\* the result of the observations of longitude which I made at Santa Cruz. The following are the data taken from Mr. de Borda's manuscript, and which will serve to complete what has been laid down in the Collection of my astronomical observations (t. i, p. xxxvii and 28). Don Joseph Varela observed, the 30th of August, at the port of Gomera, the immersion of Jupiter's third satellite, at  $15^h 40' 8''$ . Tofino saw, at Cadiz, this same immersion, at  $16^h 23' 28''$ . Difference of the meridians  $43' 20''$ ; the port of la Gomera, being situate, according to the operations of Borda  $0^h 3' 28''$  to the east of Santa Cruz, we find for this latter place  $0^h 39' 52''$ . The 12th of October, Varela observed the immersion of the third satellite at

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\* Vol. i, p. 117.



Santa Cruz at  $12^{\text{h}} 42' 11''$ . Tofino made the same observation at Cadiz at  $13^{\text{h}} 22' 26''$ . Difference of the meridians  $0^{\text{h}} 40' 15''$ . The same day the immersion of the third satellite was observed at Santa Cruz at  $15^{\text{h}} 52' 51''$ ; at Cadiz at  $16^{\text{h}} 32' 54''$ . Difference,  $0^{\text{h}} 40' 3''$ . The mean of these three observations of satellites, which had not yet been published, makes Santa Cruz  $18^{\circ} 36' 45''$  west of Paris, in reckoning with Mr. de Borda for Cadiz  $8^{\circ} 36' 0''$ , conformably to the observation of the annular eclipse of the Sun in 1764, calculated by Du Séjour. But the real longitude of the old observatory of Cadiz being, according to a great number of occultations of stars\* calculated by Messrs. Triesnecker and Oltmanns,  $8^{\circ} 37' 37''$ ; we have thence by the satellites  $18^{\circ} 38' 22''$  for the longitude of Santa Cruz. Varela and Tofino made use of two telescopes two feet and a half long, by Dollond, with which these two observers had often obtained at Cadiz exactly the same results. Two observations of the first and second satellites, made by P. Feuillée, in 1724, at Laguna and Orotava, and compared with the observations of Maraldi at Paris, give  $18^{\circ} 36' 36''$  and  $18^{\circ} 29' 11''$  for Santa Cruz in Teneriffe; supposing, with Borda, Laguna to be  $2' 50''$ , and Orotava  $16' 5''$  west of the Mole of Santa Cruz (Mém. de l'Acad., 1746, p. 123). These data, combined with the chronometrical results, concur in proving what I have enlarged on elsewhere, that the longitude of the Mole is probably not less than  $18^{\circ} 38'$ , or greater than  $18^{\circ} 36'$  or  $18^{\circ} 38'$ . Mr. de Borda, speaking in his journal of Captain Cook, whom he had the pleasure to meet at the Canaries, adds, "I cannot conceive why this celebrated navigator, who was acquainted with the determinations of the travellers who preceded him, persists in stating, that the port of Santa Cruz is in  $18^{\circ} 51' 0''$ " (Third Voyage, vol. i, p. 19). Be-

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\* Rec. d'Obs. Astron., t. i, p. 25. Espinosa, Memorias de los Navegantes, t. i, p. 45.

fore the expedition of the *Boussole* and the *Espiègle*, the latitude of the Peak of Teneriffe was generally thought to be  $28^{\circ} 12' 54''$  (Maskelyne, *Brit. Mariner's Guide*, p. 17). Cook found the Peak, by observations made under sail,  $12' 11''$  more to the South, and  $29' 30''$  more to the west, than the Mole of Santa Cruz. The geometrical operations of Borda give with more exactness  $11' 37''$  difference in latitude, and  $23' 4''$  difference in longitude. At the Mole, the Peak has been determined by azimuths West  $28^{\circ} 55'$  South; the angle of apparent height being  $4^{\circ} 37'$ . Distance 22740 toises, supposing the elevation of the volcano to be 1904 toises. Latitude of the Peak  $28^{\circ} 16' 53''$ . Longitude  $18^{\circ} 59' 54''$ . I give here all that relates to this celebrated mountain, in order to induce navigators to verify results, which are so important to nautical geography.



Mr. de Borda is the only traveller, who has compared in an accurate manner the dip of the needle at Santa Cruz, and at the top of the Peak of Teneriffe. He found the latter  $1^{\circ} 15'$  greater (Manuscrit du Dépôt, Cah. 4). This increase of the dip observed on the summit of a high mountain is conformable to what I have several times remarked in the chain of the Andes. It probably depends on some system of local attractions; but in order to form a right judgment of this phenomenon, we should know with precision the dip of the magnetic needle at the foot of the volcano, for instance at the town of Orotava. The variation in 1776 was  $15^{\circ} 45'$  at Gomera,  $15^{\circ} 50'$  at the Mole of Santa Cruz, and  $19^{\circ} 40'$  toward the north west, at the brink of the crater.

## BOOK II.

### CHAPTER IV.

*First abode at Cumana. — Banks of the  
Manzanares.*

WE anchored opposite the mouth of the river Manzanares on the 16th of July, at break of day; but we could not land till very late in the morning, because we were obliged to wait the visit of the officers of the port. Our eyes were fixed on the groups of cocoa-trees that border the river, and the trunks of which, more than sixty feet high, towered over the landscape. The plain was covered with tufts of cassias, capers, and those arborescent mimosas, which, like the pine of Italy, extend their branches in the form of an umbrella. The pinnated leaves of the palms were conspicuous on the azure of a sky, the clearness of which was unsullied by any trace of vapors. The Sun was ascending rapidly toward the zenith. A dazzling light was spread through the air, along the whitish hills strewed with cylindric cactuses, and over a sea ever calm,

the shores of which were peopled with alcatras\*, egrets, and flamingoes. The splendor of the day, the vivid color of the vegetable world, the forms of the plants, the varied plumage of the birds, every thing announced the grand aspect of nature in the equinoctial regions.

The city of Cumana, the capital of New Andalusia, is a mile distant from the *embarcadere*, or the battery of the *Bocca*, where we landed, after having passed the bar of the Manzanares. We had to cross a vast plain †, which divides the suburb of the Guayquerias from the seacoast. The excessive heat of the atmosphere was augmented by the reverberation of the soil, partly stripped of vegetation. The centigrade thermometer, plunged into the white sand, rose to 37·7°. In the small pools of salt water it kept at 30·5°, while the heat of the ocean, at it's surface, is generally in the port of Cumana ‡ from

\* Brown pelican of the size of a swan. Buffon, pl. eulum No. 957. *Pelicanus fuscus*, Lin. (Oviedo, lib. xiv, c. 6.)

† El Salado.

‡ On comparing a great number of experiments made in 1799 and 1800, at different seasons, I find, that in the port of Cumana, to the north of Cerro Colorado, the sea during the ebb, is 0·8° warmer than during the flow, whatever be the hour of the tide. I shall here give the observations of the 20th of October, which may almost serve as a type, and which were made on a point of the coast, where the sea at 150 toises distance was 30 or 40 fathoms deep. At ten in the morning, ebb 26·1°; air near the coast 27·4°; air near

25·2° to 26·3°. The first plant that we gathered on the continent of America was the *avicennia tomentosa*\*, which in this place scarcely reaches two feet high. This shrub, the *sesuvium*, the yellow *gomphrena*, and the cactus, cover the lands impregnated with muriat of soda; they belong to that small number of plants, which live in society like the heath of Europe, and which in the torrid zone are found only on the seashore, and on the elevated plains of the Andes†. The *avicennia* of Cumana is distinguished by another peculiarity not less remarkable: it furnishes an instance of a plant common to the shores of South America and the coasts of Malabar.

The Indian pilot led us across his garden, which rather resembled a copse than a piece of cultivated ground. He showed us, as a proof of the fertility of this climate, a silk-cotton tree (*bombax heptaphyllum*), the trunk of which, in it's fourth year, had reached nearly two feet and

the city 30·2°; water of the Manzanares 25·2°: at four in the afternoon, flow 25·3°; air near the coasts 26·2°; air at Cumana 28·1°; water of the Manzanares 25·7°.

\* Mangle prieto.

† On the extreme rarity of the *social plants* between the tropics, see my Essay on the Geog. of Plants, p. 19; and a paper by Mr. Brown on the *Proteaceæ* (Trans. of the Lin. Soc. vol. x, P. i, p. 23), in which this great botanist has extended and confirmed by numerous facts my ideas on the associations of plants of the same species.



a half in diameter. We have observed, on the banks of the Oroonoko and the river Magdalena, that the bombax, the carolinea, the ochroma, and other trees of the family of the malvaceæ, are of extremely rapid growth. I nevertheless think, that there was some exaggeration in the report of the Indian respecting the age of his bombax; for under the temperate zone, in the hot and damp lands of North America, between the Mississippi and the Alleghany mountains, the trees do not exceed a foot in diameter \* in ten years; and vegetation is in general but a fifth more speedy than in Europe, even taking as an example the platanus occidentalis, the tulip tree, and the cupressus disticha, which reach from nine to fifteen feet in diameter. On the strand of Cumana, in the garden of the Guayqueria pilot, we saw for the first time a *guama* † loaded with flowers, and remarkable

\* Five feet above the ground. These measures were taken by an excellent observer, Mr. Michaux.

† *Inga spuria*, which we must not confound with the common *inga*, *inga vera*, Willd. (*mimosa inga*, Lin.). The white stamina, to the number of sixty or seventy, are attached to a greenish corolla, have a silky lustre, and are terminated by a yellow anther. The flower of the *guama* is eighteen lines long. The common height of this fine tree, which prefers a moist soil, is from eight to ten toises. I shall observe on this occasion, that we have distinguished in this work by italics the names of the new plants, which Mr. Bonpland and myself have collected.

for the extreme length and silvery splendour of its numerous stamina. We crossed the suburb of the Indians, the streets of which are very regular, and formed of small houses, quite new, and of a pleasing appearance. This part of the town had just been rebuilt, on account of the earthquakes, which had laid Cumana in ruins eighteen months before our arrival. Scarcely had we passed, on a wooden bridge, the Manzanares, which contains a few *bavas*, or crocodiles of the smaller species, when we every where perceived the traces of this horrible catastrophe ; new edifices were rising on the ruins of the old.

We were conducted by the captain of the Pizarro to the governor of the province, Don Vincente Emparan, to present to him the passports which had been given us by the first secretary of state. He received us with that frankness, and that noble simplicity, which has at all times characterized the Biscayan nation. Before he was named governor of Portobello and Cumana, he had distinguished himself as captain of a vessel in the royal navy. His name recalls to mind one of the most extraordinary and distressing events recorded in the history of maritime wars. At the time of the last rupture between Spain and England, two brothers of Mr. d'Emparan fought during a whole night be-

fore the port of Cadiz, taking each other's ships for an enemy's. The battle was so terrible, that both vessels were sunk nearly at the same time. A very small part of the crew was saved, and the two brothers had the misfortune to recognize each other a little before they expired.

The governor of Cumana expressed his great satisfaction at the resolution we had taken to remain for some time in New Andalusia, the name of which province at this period was very little known in Europe, and which in it's mountains, and on the banks of it's numerous rivers, contains a great number of objects worthy of fixing the attention of naturalists. Mr. de Emparan showed us cottons dyed with native plants, and fine furniture which was made exclusively with the wood of the country: he interested himself much in every thing that related to natural philosophy; and asked, to our great astonishment, if we thought, that under the beautiful sky of the tropics, the atmosphere contained less azot (azotico) than in Spain; or if the rapidity, with which iron oxidates in those climates, was only the effect of a greater humidity indicated by the hair hygrometer. The name of his native country pronounced on a distant shore would not have been more agreeable to the ear of a traveller, than those words of azot, oxyd of iron, and hygrometer, were to ours. We knew, that, notwithstanding the orders

of the court, and the recommendations of a powerful minister, our abode in the Spanish climates would expose us to numberless inconveniences, if we did not succeed in inspiring some personal interest in those who govern those vast countries. Mr. de Emparan loved the sciences too well, to deem it strange that we should come from so great a distance to collect plants, and determine the position of a few places by astronomical methods. He suspected no other motives for our voyage than those mentioned in our passports ; and the public marks of consideration, which he gave us during a long abode in his government, contributed greatly to procure us a favourable welcome in every part of South America.

We disembarked our instruments toward the evening, and we had the pleasure to find, that none had been damaged. We hired a spacious house, the situation of which was favourable for astronomical observations. We enjoyed an agreeable coolness, when the breeze arose ; the windows were without glasses, and even wanted those paper panes, which are often the substitutes of glass at Cumana. The whole of the passengers aboard the Pizarro left the vessel, but the recovery of those who had been attacked by the fever, was very slow. We saw some, who a month after, notwithstanding the care bestowed on them by their countrymen, were

still extremely weak and reduced. Hospitality, in the Spanish colonies, is such, that, a European who arrives, without recommendation, or pecuniary means, is almost sure of finding assistance, if he lands in any port on account of sickness. The Catalans, the Gallicians, and the Biscayans, have the most frequent intercourse with America. They there form as it were three distinct corporations, which exercise a remarkable influence over the morals, the industry, and commerce of the colonies. The poorest inhabitant of Siges or Vigo is sure of being received into the house of a Catalan or Gallician *pulpero* \*, whether he arrives at Chili, or at the Philippine Islands. I have seen the most affecting instances of these attentions rendered to unknown persons, during whole years, and always without a murmur. It has been said, that hospitality was easy to be exercised in a happy climate, where food is in plenty, where the native plants yield salutary remedies, and where the sick man, reposing in his hammock, finds under a shed all the shelter of which he stands in need. But should we consider as of little value the embarrassment caused in a family by the arrival of a stranger, whose character is unknown? can we be permitted to forget those marks of tender compassion, those endearing attentions of the female part of the household,

\* A retail dealer.



that untired patience, which never relaxes during a long and painful recovery? It has been remarked, that, with the exception of a few very populous towns, hospitality has not yet perceptibly diminished since the first establishment of the Spanish colonists in the new world. It is distressing to think, that this change will take place, when population and colonial industry shall have made more rapid progress; and that this state of society, which we are agreed to call an advanced state of civilization, will by degrees have banished "the Old Castilian frankness."

Among the sick who landed at Cumana was a negro, who fell into a state of insanity a few days after our arrival; he died in this deplorable condition, though his master, almost seventy years old, who had left Europe to settle at Sans Blas, at the entrance of the gulf of California, had attended him with the greatest care. I relate this fact as a proof of it's sometimes happening that men born under the torrid zone, after having dwelt in temperate climates, feel the pernicious effects of the heat of the tropics. The negro was a young man, eighteen years of age, very robust, and born on the coast of Guinea: an abode of some years on the high plain of Castile, and given his organization that kind of irritability, which renders the miasms

of the torrid zone so dangerous to the inhabitants of the countries of the north.

The soil, on which Cumana is built, forms part of an extent of ground, that is very remarkable in a geological point of view. As since my return to Europe, other travellers have preceded me in the description of certain parts of the coasts, which they have visited after me, I shall here confine myself to observations on subjects, that have formed no part of their studies. The chain of the calcareous Alps of Bergantin and Tataraqual stretches east and west from the summit of Impossible to the port of Mochima and to Campanario. The sea, in times far remote, appears to have divided this chain of the rocky coasts of Araya and Maniquarez. The vast gulf of Cariaco is owing to an irruption of the sea ; and no doubt can be entertained, but that at this period the waters covered, on the southern bank, the whole of the ground impregnated with muriat of soda, through which flows the Manzanares. It requires but a slight inspection of the topographical plan of the city of Cumana, to render this fact as incontestable as the ancient abode of the sea on the basins of Paris, Oxford, and Rome. The slow retreat of the waters has turned into dry ground this extensive plain, in which rises a group of small hills, composed of gypsum and calcareous breccia of very recent formation.

The city of Cumana is backed by this group, which was formerly an island of the gulf of Cariaco. That part of the plain, which is north of the city, is called *Plaga Chica*, and extends eastward as far as *Punta Delgada*; where a narrow valley, covered with yellow gomphrena, still marks the point of the ancient outlet of the waters. This valley, the entrance of which is defended by no exterior works, is the point, where the place is most exposed to a military attack. An enemy might pass in perfect safety between the sandy point of Barigon \* and the mouth of the Manzanares; where the sea, near the entrance of the gulf of Cariaco, is forty or fifty fathoms deep, and farther to the south-east, even as much as eighty-seven fathoms. A landing might be effected near Punta Delgada; and Fort St. Antonio and the city of Cumana turned, without any apprehension from the western batteries formed at Plaga Chica †, at the mouth of the river, and at Cerro Colorado.

The hill of calcareous breccia, which we have just regarded as an island in the ancient gulf, is covered with a thick forest of columnar cactus and opuntia. Some, thirty or forty feet high, covered with lichens, and divided into several branches in the form of candelabras, wear a

\* Punta Arenas del Barigon, to the south of the castle of Araya.

† To the west of Los Serritos.

singular appearance. Near Maniquarez, at Punta Araya, we measured a cactus, the trunk of which was four feet nine inches in circumference \*. A European acquainted only with the opuntia in our hot-houses is surprised to see the wood of this plant become so hard from age, that it resists for centuries both air and moisture, and that the Indians of Cumana employ it in preference for oars and door posts. Cumana, Coro, the island of Margareta, and Curassoa, are the places of South America that abound most in plants of the family of the nopals. There only a botanist after a long residence could compose a monography of the genus cactus, the species of which vary not only in their flowers and fruits, but in the form of their articulated stem, the number of costæ, and the disposition of the thorns. We shall see hereafter how these plants, which characterize a warm and extraordinarily dry climate, like that of Egypt and California, gradually disappear in proportion as we remove from the coasts, and penetrate into the inland country.

The groups of cactus and opuntia produce the same effect in the arid lands of equinoxial America, as the juncæ and the hydrocharides in the marshes of our northern climes. A place

\* Tuna macho. We distinguish in the wood of the cactus the medullary prolongations, as Mr. Desfontaines has already observed (Journ. de Physique, t. xlviii, p. 153).

where the larger species of the strong cactus are collected in groups is considered as almost impenetrable. These places, called *tunales*, are impervious not only to the native, who goes naked to the waist, they are formidable even to those who go fully clothed. In our solitary rambles, we sometimes endeavoured to penetrate into the tunal that crowns the summit of the castle hill, a part of which is crossed by a pathway, where we might study, amidst thousands, the organization of this singular plant. Sometimes the night suddenly overtook us, for there is scarcely any twilight in this climate; and we then found ourselves in a situation so much the more disagreeable, as the *cascabel* or rattlesnake\*, the *coral*, and other vipers, armed with poisonous fangs, frequent, at the time of laying, these scorched and arid haunts, to deposit their eggs in the sand.

The castle of St. Antonio is built at the eastern extremity of the hill, but not on the most elevated point, being commanded on the east by an unfortified summit. The tunal is considered both here and every where in the Spanish colonies as a very important means of military defence; and when earthen works are raised, the engineers are eager to propagate the

\* *Crotalus cumanensis*, &c. *Lœflingii*, two new species. See my *Recueil d'Observ. Zoologiques*, t. ii, p. 8.



thorny opuntia, and promote it's growth, as they are careful to keep crocodiles in the ditches of fortified places. Under a climate where organized nature is so powerful and active, man summons as auxiliaries in his defence the carnivorous reptile, and the plant with it's armor of formidable thorns.

The castle of St. Antonio, on which the Spanish flag is hoisted on festivals, is only thirty toises above the level of the waters in the gulf of Cariaco\*. Placed on a naked and calcareous hill, it commands the town, and forms a very picturesque object to vessels entering the port. It forms a bright object against the dark curtains of those mountains, which raise their summits to the region of the clouds, and of which the vaporous and bluish tint blends itself with the azure of the sky. On descending from Fort St. Antonio toward the south-west, we find on the slope of the same rock the ruins of the old castle of St. Mary. This site is delightful to those, who wish to enjoy, toward sunset, the freshness of the breeze, and the view of the gulf.

\* This elevation is concluded from the zenith distance of the staff on which signals are hoisted. I found in the great square of Cumana this angle, not corrected for refraction,  $83^{\circ} 2' 10''$ . According to the topographical plan of Cumana, laid down in 1793 by Mr. Fidalgo, the horizontal distance of the Gran Plaza from the Castillo de San Antonio is 220 toises.

The lofty summits of the island of Margareta\* present themselves above the rocky coast of the isthmus of Araya : toward the west, the small islands of Caraccas, Picuita, and Boracha, recall to mind the catastrophes, that have overwhelmed the coasts of Terra Firma. These islets bear the resemblance of fortifications, and from the effect of the mirage, while the inferior strata of the air, the ocean, and the soil, are unequally heated by the Sun, their points appear raised like the extremity of the great promontories of the coast. It is pleasing, during the day, to follow these inconstant phenomena†; we see, as the night approaches, these stony masses, that had been suspended in the air, settle themselves on their bases; and the luminary, the presence of which vivifies organic nature, seems by the variable inflection of it's rays, to impress motion on the stable rock, and give an undulating movement to plains covered with arid sands.

The city of Cumana, properly speaking, occupies the ground that lies between the castle of St. Antonio, and the small rivers of Manzanares and Santa Catalina. The Delta, formed

\* The promontory of Macanao.

† The real cause of the mirage, or the extraordinary refraction which the rays undergo, when strata of air of different densities are placed on each other, had already been suspected by Hooke. See his Posthumous Works, p. 472.

by the bifurcation of the first of these rivers, is a fertile plain covered with mammees, sapotas (*achras*), plantains, and other plants cultivated in the gardens or *sharas* of the Indians. The town has no remarkable edifice, and the frequency of earthquakes forbids such embellishments. It is true, that strong shocks occur less frequently in a given time at Cumana, than at Quito, where we nevertheless find sumptuous and very lofty churches. But the earthquakes of Quito are violent only in appearance; and, from the particular nature of the motion and of the ground, no edifice there is overthrown. At Cumana, as well as at Lima, and in several cities placed far from the mouths of burning volcanoes, it happens, that the series of slight shocks is interrupted after a long course of years by great catastrophes, that resemble the effects of the explosion of a mine. We shall have occasion to return several times to this phenomenon, for the explanation of which so many vain theories have been imagined, and which have been thought to be classed, by attributing them to perpendicular and horizontal movements, to the shock, and to oscillation\*.

\* This classification dates from the time of Posidonius. It is the *succussio* and *inclinatio* of Seneca (Nat. Quæst. 6, c. 21): but the ancients had already judiciously remarked, that the nature of these shocks is too variable, to permit any

The suburbs of Cumana are almost as populous as the ancient town. We reckon three, that of the Serritos, on the road to the Plaga Chica, where we meet with some fine tamarind trees; that of St. Francis, toward the south-east; and the great suburb of the Guayquerias, or Guayguerias. The name of this tribe of Indians was quite unknown before the conquest. The natives who bear this name formerly belonged to the nation of the Guaraounoes, of which we find no remains but in the swampy lands of the branches of the Oronoko. Old men have assured me, that the language of their ancestors was a dialect of the Guaraouno; but that for a century past no native of that tribe at Cumana, or in the island of Margareta, has spoken any other language than the Castilian.

The denomination of Guayquerias, like those of Peru and Peruvian, owes its origin to a mere mistake. The companions of Christopher Columbus, coasting along the island of Margareta, where still on the northern coasts resides the noblest portion of the Guayqueria nation\*, met a few natives, who were harpooning fish by

subjection to those imaginary laws. (Plato, apud Plut. de Placit. Philos., lib. iii, c. 15, ed. Reiske, t. ix, p. 551.)

\* The Guayquerias of la Banda del Norte consider themselves as the most noble race, because they think, that they are less mixed with the Chayma Indian, and other copper-

throwing a pole tied to a cord, and terminated by an extremely sharp point. They asked them in the Hayti language their name; and the Indians, thinking that the question of the strangers related to their harpoons, formed of the hard and heavy wood of the *macana* palm tree, answered *guaike*, *guaike*, which signifies *pointed pole*. A striking difference at present exists between the Guayquerias, a civilized tribe of skilful fishermen, and those savage Guaraounoes of the Oroonoko, who suspend their habitations on the trunks of the mauritia palm tree, *moriche*.

The population of Cumana has been singularly exaggerated in latter times. In 1800, several colonists, little versed in questions of political economy, carried this population to twenty thousand souls; while the king's officers employed in the government of the country thought, that the city with it's suburbs did not

coloured races. They are distinguished from the Guayquerias of the continent by their manner of pronouncing the Spanish, which they speak almost without separating their teeth. They show with pride to Europeans the point of the Galera, so called on account of the vessel of Columbus, which anchored there, and the port of Manzanillo, where they first swore to the Whites, in 1493, that friendship, which they have never betrayed, and which has given them, in the Court style, the title of *fieles*, loyal. (See above, p. 44.)



contain twelve thousand. Mr. Depons, in his valuable work on the province of Caraccas, gives Cumana, in 1802, near twenty-eight thousand inhabitants; others have carried this number, for the year 1810, to thirty thousand. When we consider the slowness, with which the population increases in Terra Firma, I do not speak of the country, but in the towns, we must doubt whether Cumana be already a third more populous than Vera Cruz, the principal port of the vast kingdom of New Spain. It is even easy to prove, that in 1802 the population scarcely exceeded eighteen or nineteen thousand souls. I was favoured with a sight of the different memoirs, which the government had procured to be drawn up on the statistics of the country, at the time when the question was agitated, whether the revenue of the farm of tobacco could be replaced by a personal tax; and I flatter myself, that my estimation rests on solid foundations.

An enumeration made in 1792 gives Cumana but 10740 inhabitants, reckoning the suburbs and scattered houses a league around. Don Manuel Navarete, an officer of the treasury, asserts, that the error of this enumeration cannot be a third, or even a fourth of the whole number. On comparing the annual registers of baptisms, we observe but a feeble increase from 1790 to 1800. The women, it is true, are extremely

fruitful, especially the natives ; but though the small-pox be yet unknown in this country, the mortality of infants is prodigious, on account of the extreme carelessness in which they live, and the pernicious custom of eating green and indigestible fruits. The number of births\* generally amounts from five hundred and twenty to six hundred, which indicates at most a population of sixteen thousand eight hundred souls. We may be assured, that all the Indian children are baptised, and inscribed on the registers of the parishes ; and supposing, that the population in 1800 had been twenty-six thousand souls, there would have been but one single birth to forty-three individuals ; while the ratio of births to the whole population is in France as twenty-eight to a hundred, and in the equinoctial regions of Mexico as seventeen to a hundred.

It is to be presumed, that the Indian suburb

\* The following are the results which I drew from the registers communicated to me by the parish priests of Cumana. Births in the year 1798, in the district of the *Curas rectores*, 237 ; in the district of the *Curas castrenses*, 57 ; in the suburb of the Guayquerias, or parish of Alta Gracia, 209 : in the suburb of the Serritoes, or parish of Socorro, 19. Total 522. We see, by these parish registers, the great fecundity of the Indian marriages : for though the suburb of the Guayquerias contains a number of individuals of other tribes, we are struck with the quantity of children born on this left bank of the Manzanares. Their number amounts to two fifths of the whole births.

by degrees will extend as far as the *Embarcadere*, the plain, which is not yet covered with houses or huts, being more than 340 toises in length\*. The heats are somewhat less oppressive on the side toward the seashore, than in the old town, where the reverberation of the calcareous soil, and the proximity of the mountain of St. Antonio, raise the temperature to an extraordinary degree. In the suburb of the Guayquerias, the sea breezes have free access; the soil is clayey, and, as it is thought, less exposed from this reason to the violent shocks of earthquakes, than the houses at the foot of the rocks and hills on the right bank of the Manzanares.

The shore near the mouth of the small river Santa Catalina is bordered with mangrove trees†, but these mangroves are not sufficiently

\* I have deduced this distance from the vertical angles and the azimuths of several edifices, of which I carefully measured the height. On the side of the river, in 1800, the distance from the first hut of the suburbs of the Guayquerias in the Casa blanca (of Don Pasqual Goda) was 538 toises, and from this first hut to the bridge of the Manzanares 210 toises. These data will one day be interesting, when the progress of industry and prosperity at Cumana, from the beginning of the nineteenth century, becomes a subject of inquiry.

† *Rhizophora mangle*. Mr. Bonpland found on the Plaga Chica the *allionia incarnata*, in the same place where the unfortunate Lœffling had discovered this new genus of nyctagines.

spread to diminish the salubrity of the air of Cumana. The soil of the plain is in part destitute of vegetation, in part covered with tufts of *sesuvium portulacastrum*, *gomphrena flava*, *g. myrtifolia*, *talinum cuspidatum*, *t. cumanense*, and *portulaca lanuginosa*. Among these herbaceous plants we find at intervals the *avicennia tomentosa*, the *scoparia dulcis*, a frutescent *mimosa* with very irritable leaves\*, and particularly cassias, the number of which is so great in South America, that we collected, in our travels, more than thirty new species.

On leaving the Indian suburb, and ascending the river toward the south, we found a grove of cactus, a delightful spot, shaded by tamarinds, brasillettoes, bombax, and other plants, remarkable for their leaves and flowers. The soil here is rich in pasturage, where dairy houses, built with reeds, are separated from each other by clumps of trees. The milk remains fresh, when kept, not in the calabashes† of very thick ligneous fibres, but in porous earthen vessels from Maniquarez. A prejudice prevalent in the

\* The Spaniards designate by the name of *dormideras* (sleeping plants) the small number of *mimosas* with irritable leaves. We have increased this number with three species, which were unknown to botanists, namely, the *mimosa humilis* of Cumana, the *m. pellita* of the savannahs of Calabozo, and the *m. dormiens* of the banks of the Apura.

† The fruit of the *crescentia cujete*.

countries of the north had long led me to believe, that cows, under the torrid zone, did not yield rich milk ; but my abode at Cumana, and especially an excursion through the vast plains of Calabozo, covered with grasses, and herbaceous sensitive plants, convinced me, that the ruminating animals of Europe become perfectly habituated to the most scorching climates, provided they find water and good nourishment. The milk is excellent in the provinces of New Andalusia, Barcelona, and Venezuela ; and the butter is better in the plains of the equinoctial zone, than on the ridge of the Andes, where the Alpine plants, enjoying in no season a sufficiently high temperature, are less aromatic than on the Pyrenees, the mountains of Estremadura, and those of Greece. As the inhabitants of Cumana prefer the coolness of the sea breeze to the appearance of vegetation, they are accustomed to no other walk than that of the open shore. The Spaniards, who are accused in general of no predilection for trees, or the warbling of birds, have transported their prejudices and their habits into the colonies. In Terra Firma, Mexico, and Peru, it is rare to see a native plant a tree, merely with the view of procuring himself shade ; and if we except the environs of the great capitals, walks bordered with trees are almost unknown in these countries. The arid plain of Cumana exhibits after violent showers an extra-



ordinary phenomenon. The earth, drenched with rain, and heated again by the rays of the sun, emits that musky odour, which under the torrid zone is common to animals of very different classes, to the jaguar, the small species of tiger cat, the thick-nosed tapir\*, the galinazo vulture†, the crocodile, vipers, and rattlesnakes. The gaseous emanations, which are the vehicles of this aroma (odour), seem to be evolved in proportion only as the mould, containing the spoils of an innumerable quantity of reptiles, worms, and insects, begins to be impregnated with water. I have seen Indian children, of the tribe of the Chaymas, draw out from the earth and eat millepedes or scolopendras ‡ eighteen inches long, and seven lines broad. Whenever the soil is turned up, we are struck with the mass of organic substances, which by turns are developed, transformed, and decomposed. Nature in these climates appears more active, more fruitful, we might even say more prodigal of life.

On this shore, and near the dairies of which we have just spoken, we enjoy, especially at sun-

\* *Cavia capybara*, Lin. ; chiguire.

† *Vultur aura*, Lin., zamuro, or galinazo. The Brazilian vulture of Buffon. I cannot reconcile myself to the adoption of names, which designate as belonging to a single country animals common to a whole continent.

‡ Scolopendras are very common behind the castle of St. Antonio, on the summit of the hill.

rise, a very beautiful prospect over an elevated group\* of calcareous mountains. As this group subtends an angle of three degrees only at the house where we dwelt, it long served me to compare the variations of the terrestrial refraction with the meteorological phenomena. Storms are formed in the centre of this Cordillera; and we see from afar thick clouds resolve themselves into abundant rains, while during seven or eight months not a drop of water falls at Cumana. The Brigantine, which is the highest part of this chain, raises itself in a very picturesque manner

\* If the Brigantine (*Cerro del Bergantin*) be actually 24 miles, or 22800 toises distant from Cumana, as is indicated on the chart of Mr. Fidalgo, published by the Hydrographical Depôt at Madrid, in 1805, the angles of altitude which I took at the *Plaga Grande* make this mountain 1255 toises high. But this very chart, less accurate with regard to places distant from the coasts than to the coasts themselves, assigns the town of Cumanacoa a latitude of  $10^{\circ} 5'$ , while, according to my direct observations, it is  $10^{\circ} 16' 11''$ . (Obs. Astron. t. i, p. 96.) If this too southern position has an influence on that of the Brigantine, we must admit, that this mountain is much lower. It presents itself at the *Plaga Grande* under a vertical angle (corrected for the refraction and curve of the Earth) of  $3^{\circ} 6' 12''$ . Other angles, taken on a base of 196 toises, which was measured on ground where the water had rested a long time, would induce me to think, that the height and distance of the Brigantine are not much above 800 toises, and 12 or 16 miles; but we can have no confidence in so short a basis, and an operation, the immediate object of which was not the measure of the Brigantine.

behind Brito and Tataraqual. It took its name from the form of a very deep valley on the northern declivity, which resembles the inside of a ship. The summit of this mountain is almost bare of vegetation, and flattened like that of Mowna-Roa, in the Sandwich Islands. It is a perpendicular wall, or, to use a more expressive term of the Spanish navigators, a table, *mesa*. This peculiar physiognomy, and the symmetrical arrangement of a few cones, which surround the Brigantine, made me at first think, that this group, which is wholly calcareous, contained rocks of basaltic or trappean formation.

The governor of Cumana had sent, in 1797, a band of determined men to explore this entirely desert country, and to open a direct road to New Barcelona, by the summit of the *Mesa*. It was reasonably expected, that this way would be shorter, and less dangerous to the health of travellers, than that which was pursued by the couriers along the coasts; but every attempt to cross the chain of the mountains of the Brigantine was fruitless. In this part of America, as in New Holland \* to the west of Sidney Town, it is not so much the height of the Cordilleras,

\* The blue mountains of New Holland, and those of Carmarthen and Lansdown, are not visible, in clear weather beyond fifty miles. Peron. Voyage aux Terres Australes, p. 389. Supposing the angle of altitude half a degree, the absolute height of these mountains would be about 620 toises.

as the form of the rocks, that presents obstacles difficult to surmount.

The longitudinal valley, formed by the lofty mountains of the interior and the southern declivity of the Cerro de San Antonio, is traversed by the Rio Manzanares. This plain, which is the only thoroughly wooded part in the environs of Cumana, is called the Plain des Charas\*, on account of the numerous plantations, which the inhabitants have begun for some years past along the river. A narrow path leads from the hill of San Francisco across the forest to the *hospice* of the Capuchins, a very agreeable country house, which the Arragonese monks have built as a retreat for old infirm missionaries, who can no longer fulfil the duties of their ministry. As we advance toward the west, the trees of the forest become more vigorous, and we meet with a few monkeys†, which, however, are very rare in the environs of Cumana. At the foot of the capparais, the bauhinia, and the zygo-phylum with flowers of a gold yellow, extend a carpet of bromelia‡, akin to the b. karatas, which from the odour and coolness of it's foliage attracts the rattlesnake.

The waters of the Manzanares are very limpid,

\* *Chacra*, by corruption *chara*, a hut or cottage surrounded by a garden. The word *ipure* has the same signification.

† The common *machi*, or weeping monkey.

‡ *Chihuchihue*, of the family of the ananas.

and happily it has no resemblance whatever to the Manzanares of Madrid, which appears the narrower from the contrast of the sumptuous bridge by which it is crossed. It takes its source, like all the rivers of New Andalusia, in a part of the savannahs (llanos) known by the names of the *plateaux* of Jonoro, Amana, and Guanipa \*, which receives, near the Indian village of San Fernando, the waters of the Rio Juanillo. It has been several times proposed to the government, but always without success, to construct a dyke at the first *Ipure*, in order to form artificial irrigations in the plain of Charas; because, notwithstanding its apparent sterility, the soil is extremely productive, wherever humidity is joined to the heat of the climate. The cultivators, who are but in narrow circumstances at Cumana, were gradually to refund the money advanced for the construction of the sluices. Meanwhile Persian wheels, pumps worked by mules, and other hydraulic but imperfect machines, have been erected, to serve till this project is carried into execution.

The banks of the Manzanares are very pleasant, and shadowed by mimosas, erythrinas ceibas, and other trees of gigantic growth. A ri-

\* These three eminences bear the names of *Mesas*, tables. An immense plain has an almost imperceptible rise from both sides to the middle, without any appearance of mountains or hills.



ver, the temperature of which, in the season of the floods, descends as low as twenty-two degrees, when the air is at thirty and thirty-three degrees, is an inestimable benefit, in a country where the heats are excessive during the whole year, and where it is so agreeable to bathe several times in the day. The children pass, as it were, a part of their lives in the water: the whole of the inhabitants, even the women of the most opulent families, know how to swim; and in a country where man is so near the state of nature, one of the first questions asked at first meeting in the morning is, whether the water is cooler than the preceding evening. The mode of bathing is various enough. We every evening visited a very respectable society, in the suburb of the Guayquerias. In a fine moonlight night, chairs were placed in the water: the men and women were lightly clothed, as in some baths of the north of Europe; and the family and strangers, assembled in the river, passed some hours in smoking segars, and in talking, according to the custom of the country, of the extreme dryness of the season, of the abundant rains in the neighbouring districts, and particularly of the luxuries, of which the ladies of Cumana accuse those of the Caraccas and the Havannah. The company were under no apprehensions from the bavas, or small crocodiles, which are now extremely scarce, and which approach men with-

out attacking them. These animals are three or four feet long. We never met with them in the Manzanares, but with a great number of dolphins \*, which sometimes ascend the river in the night, and frighten the bathers by spouting water.

The Port of Cumana is a road capable of receiving all the navies of Europe. The whole of the Gulf of Cariaco, which is thirty-five miles long, and sixty-eight miles broad, affords excellent anchorage. The great ocean is not more calm and pacific on the coasts of Peru, than the sea of the Antilles from Portocabello, and especially from Cape Codera, to the Point of Paria. The hurricanes of the West Indies are never felt in these regions, the vessels of which are without decks. The only danger in the port of Cumana is a shoal, that of Morro Roxo †, which is nine hundred toises broad from east to west,

\* Toninas.

† There are from one to three fathoms water on this shoal, while just beyond it's edges there are eighteen, thirty, and even thirty-eight. The remains of an old battery, situate to the north-north-east of the castle of St. Antonio, and very near it, serve as a mark to avoid the bank of Morro Roxo. Before this battery shuts in with a very high mountain of the peninsula of Araya, which bears from the castle of St. Antonio, north  $65^{\circ} 30'$  east, at six leagues distance, the ship must be put about. If this be neglected, the danger of striking is so much the greater, as the heights of Bordones keep the wind from a vessel steering for the port.

and so steep, that you are upon it almost before you have any warning of it.

I have been somewhat diffuse in my description of the site of Cumana, because it appeared to me important to make known a place, which for ages has been the focus of the most tremendous earthquakes. Before I speak of these extraordinary phenomena, it will be useful to collect the scattered traits of the physical position of which I have just given the sketch.

The city, placed at the foot of a hill destitute of verdure, is commanded by a castle. No steeple or dome attracts from afar the eye of the traveller, but only a few trunks of tamarind, cocoa, and date trees, which rise above the houses, the roofs of which are flat. The surrounding plains, especially those on the coasts, wear a melancholy, dusty, and arid appearance, while a fresh and luxuriant vegetation points out from afar the windings of the river, which separates the city from the suburbs, the population of European and mixed race from the natives with a coppery tint. The hill of fort St. Antonio, solitary, white, and bare, reflects a great mass of light, and of radiant heat : it is composed of breccia, the strata of which contain pelagian petrifications. In the distance, toward the south, a vast and gloomy curtain of mountains stretches along. These are the high calcareous Alps of New Andalusia, surmounted by

sandstone, and other more recent formations. Majestic forests cover this Cordillera of the interior, and are joined by a woody vale to the open, clayey lands, and salt marshes of the environs of Cumana. A few birds of considerable size contribute to give a particular physiognomy to these countries. On the seashore, and in the gulf, we find flocks of fishing herons, and alcatras of a very unwieldy form, which swim, like the swan, raising their wings. Nearer the habitation of men, thousands of galinazo vultures, the true jackals of the winged tribe, are ever busy in uncovering the carcasses of animals \*. A gulf, which contains hot and submarine springs, divides the secondary from the primary and schistose rocks of the peninsula of Araya. Each of these coasts is bathed by a tranquil sea, of an azure tint, and always gently agitated by the same wind. A bright and clear sky, with a few light clouds at sunset, reposes on the ocean, on the peninsula destitute of trees, and on the plains of Cumana, while we see the storms accumulate and descend in fertile showers among the inland mountains. Thus on these coasts, as well as at the foot of the Andes, the earth and the skies offer the extremes of clear weather and fogs, of drought and torrents of rain, of absolute nudity and never ceasing verdure. In the New

\* Buffon, *Hist. Nat. des Oiseaux*, t. i, p. 114.

Continent, the low regions on the seacoasts differ as widely from the inland mountainous districts, as the plains of Lower Egypt from the high lands of Abyssinia.

The analogies which we have just indicated, between the seacoasts of Andalusia and those of Peru, extend themselves also to the frequency of earthquakes, and the limits which nature seems to have prescribed to these phenomena. We have ourselves felt very violent shocks at Cumana; and, at the moment while the edifices recently overthrown were rebuilding, we were informed on the spot of the most minute circumstances, that accompanied the great catastrophe of the 14th of December, 1797. These observations will be perhaps the more interesting, as earthquakes have hitherto been considered rather in the fatal effects which they have had on the population and welfare of society, than under a physical and geological point of view.

It is a very generally received opinion on the coasts of Cumana, and in the island of Margaritta, that the gulf of Cariaco owes it's existence to a rent of the continent attended by an irruption of the ocean. The remembrance of his great revolution was preserved among the Indians to the end of the fifteenth century : and it is related, that, at the time of the third voyage of Christopher Columbus, the natives mentioned it as a very recent event. In 1530, the inhabi-



tants were alarmed by new shocks on the coasts of Paria and Cumana. The lands were inundated by the sea, and the small fort, built by James Castellon at New Toledo \*, was entirely destroyed. At the same time an enormous opening was formed in the mountains of Cariaco, on the shores of the gulf that bears this name, when a great body of salt water, mixed with asphaltum, issued from the micaceous schist †. Earthquakes were very frequent toward the end of the sixteenth century; and, according to the traditions preserved at Cumana, the sea often inundated the shores, rising from fifteen to twenty fathoms. The inhabitants fled to the Cerro of San Antonio, and to the hill where now stands the small convent of St. Francis. It is even thought, that these frequent inundations induced the inhabitants to build that quarter of the town, which is backed by the mountain, and stands on a part of it's declivity.

As no record exists at Cumana, and it's ar-

\* This was the first name given to the city of Cumana (Girolamo Benzoni, *Hist. del Mondo nuovo*, p. 3, 31, and 33). James Castellon arrived at St. Domingo in 1521, after the appearance of the celebrated Bartholomew de las Casas in these countries. On attentively reading the narratives of Benzoni and Caulin, we find that the fort of Castellon was built near the mouth of the Manzanares (alla ripa del fiume de Cumana): and not, as some modern travellers have asserted, on the mountain where now stands the castle of St. Antonio.

† Herera, *Description de las Indias*, p. 14.

chives, on account of the continual devastations of the termites, or white ants, contain no document, that goes back farther than a hundred and fifty years, we are unacquainted with the precise dates of the ancient earthquakes. We only know, that, in times nearer our own, the year 1776 was at the same time the most fatal to the colonists, and the most remarkable for the natural history of the country. A drought, like those which are felt at times in the islands of Cape Verd, had reigned during fifteen months, when, on the 21st of October, 1766, the city of Cumana was entirely destroyed. The remembrance of this day is every year renewed by a religious festival, attended with a solemn procession. The whole of the houses were overturned in the space of a few minutes, and the shocks were hourly repeated during fourteen months. In several parts of the province the earth opened, and threw out sulphureous waters. These irruptions were very frequent in a plain extending toward Casanay, two leagues to the east of the town of Cariaco, and known by the name of the *hollow ground*, *tierra hueca*, because it appears entirely undermined by thermal springs. During the years 1766 and 1767, the inhabitants of Cumana encamped in the streets; and they began to rebuild their houses, when the earthquakes took place only once a month. What was felt at Quito, immediately after the

great catastrophe of the 4th of February, 1797, took place on these coasts. While the ground was in a state of continual oscillation, the atmosphere seemed to dissolve itself into water. The rivers were swollen by these sudden torrents of rain, the year was extremely fertile, and the Indians, whose frail huts easily resist the strongest shocks, celebrated from ideas of an old superstition, with feasting and dances, the destruction of the world, and the approaching epocha of it's regeneration.

Tradition states, that in the earthquake of 1766, as well as in another very remarkable one in 1794, the shocks were mere horizontal oscillations; it was only on the disastrous day of the 14th of December, 1797, that for the first time, at Cumana, the motion was felt by the raising up of the ground. More than four-fifths of the city were then entirely destroyed; and the shock, attended by a very loud subterraneous noise, resembled, as at Riobamba, the explosion of a mine at a great depth. Happily the most violent shock was preceded by a slight undulating motion, so that the greater part of the inhabitants could escape into the streets, and a small number only perished of those who had assembled in the churches. It is a generally received opinion at Cumana, that the most destructive earthquakes are announced by very feeble oscillations, and by a hollow sound, which does not escape the

observation of persons habituated to this kind of phenomenon. In this fatal moment, the cries of *misericordia, tembla, tembla* \*, are every where heard ; and it is very rarely, that a false alarm is given by a native. Those who are most fearful attentively observe the motions of dogs, goats, and swine. The last of these animals, endowed with delicate olfactory nerves, and accustomed to turn up the earth, give warning of approaching danger by their restlessness and their cries. We shall not decide, whether, placed nearer the surface of the ground, they are the first that hear the subterraneous noise ; or whether their organs receive the impression of some gaseous emanation which issues from the earth. We cannot deny the possibility of this latter cause. During my abode at Peru, a fact was observed in the inland country, which has an analogy with this kind of phenomenon, and which is not unfrequent. At the end of violent earthquakes, the herbs that cover the savannahs of Tucuman acquired noxious properties ; an epidemic disorder took place among the cattle, and a great number among them appeared stupified or suffocated by the deleterious vapours exhaled from the ground.

At Cumana, half an hour before the catastrophe of the 14th of December, 1797, a strong

\* Mercy ! the earth trembles.

smell of sulphur was perceived near the hill of the convent of St. Francis ; and on the same spot a subterraneous noise, which seemed to proceed from the south-east to the north-west, was heard the loudest. At the same time flames appeared on the banks of the Manzanares, near the hospice of the Capuchins, and in the gulf of Cariaco, near Mariguitar. This last phenomenon, so extraordinary in a country not volcanic, is pretty frequent in the Alpine calcareous mountains near Cumanacoa, in the valley of Bordones, in the island of Margareta, and amidst the *Llanos*\* or savannahs of New Andalusia. In these savannahs flakes of fire rise to a considerable height ; they are seen for hours together in the driest places ; and it is asserted, that, on examining the ground which furnishes the inflammable matter, no crevice is to be found. This fire, which resembles the sources of hydrogen, or *Salse*, of Modena †, or what is called the Will o' the wisp of our marshes, does not burn the grass ; because, no doubt the column of gas, which develops itself, is mixed with azot, and carbonic acid, and does not burn at it's basis. The people, although less superstitious here than in Spain, call these reddish flames by the singu-

\* In the Mesa of Cari, to the north of Aguasay, and in the Mesa of Guanipa, far from the *Morichales*, which are the humid spots where the mauritia palm-tree grows.

† Brieslak, *Geologia*, t. ii, p. 284.



lar name of the *soul of the tyrant Aguirre* ; imagining that the spectre of Lopez Aguirre, harassed by remorse, wanders over these countries sullied by his crimes \*.

The great earthquake of 1797 produced some changes in the configuration of the shoal of Morro Roxo, toward the mouth of the Rio Bordones. Similar swellings were observed at the time of the total ruin of Cumana, in 1766. At this period, the Punta Delgado, on the southern coast of the gulf of Cariaco, was perceptibly enlarged ; and in the Rio Guarapiche, near the vilage of Maturin, a shoal was formed, no doubt by the action of the elastic fluids, which displaced and raised up the bed of the river.

We shall not continue to describe with minuteness the local changes produced by the different earthquakes of Cumana. In order to follow a plan conformable to the end we proposed in this work, we shall endeavour to generalize our

\* When at Cumana, or in the island of Margarett, the people pronounce the words *el tyranno* (the tyrant), it is always to denote the infamous Lopez d'Aguirre ; who, after having taken part, in 1560, in the revolt of Ferdinando de Guzman against Pedro de Ursua, governor of the Omeguas and Dorado, gave himself the title of *traidor*, or traitor. He descended the river of the Amazons with his band, and reached by a communication of the rivers of Guyana, of which we shall hereafter speak, the island of Margarett. The port of Paraguache still bears, in this island, the name of the Tyrant's Port.

ideas, and comprehend in one point of view every thing that relates to these phenomena, so terrific, and so difficult to explain. If it be the duty of those natural philosophers, who visit the Alps of Switzerland, or the coasts of Lapland, to extend our knowledge respecting the glaciers and the aurora borealis, it may be expected, that a traveller, who has traversed Spanish America, should have chiefly fixed his attention on volcanoes and earthquakes. Each part of the Globe is an object of particular study ; and when we cannot hope to penetrate the causes of natural phenomena, we ought at least to endeavour to discover their laws, and distinguish, by comparison of numerous facts, what is constant and uniform from what is variable and accidental.

The great earthquakes, which interrupt the long series of slight shocks, appear to have no regular periods at Cumana. They have taken place at intervals of fourscore, a hundred, and sometimes less than thirty years ; while on the coasts of Peru, for instance at Lima, a certain regularity is observed in the periods of the total ruin of the city. The belief of the inhabitants in the existence of this uniformity has a happy influence on public tranquillity, and the encouragement of industry. It is generally admitted, that it requires a sufficiently long space of time for the same causes to act with the same energy ; but this reasoning is just only in as much as the

shocks are considered as a local phenomenon ; and as a particular focus, under each point of the Globe exposed to those great catastrophes, is admitted. Wherever new edifices are raised on the ruins of the old, we hear from those who refuse to build, that the destruction of Lisbon on the first of November, 1755, was soon followed by a second, and not less fatal, on the 31st of March, 1761.

It is a very old \* and commonly received opinion at Cumana, Acapulco, and Lima, that a perceptible connection exists between earthquakes, and the state of the atmosphere that precedes these phenomena. On the coasts of New Andalusia, the inhabitants are alarmed, when, in excessively hot weather, and after long droughts, the breeze suddenly ceases to blow, and the sky, clear, and without clouds at the zenith, exhibits near the horizon, at six or eight degrees elevation, the appearance of a reddish vapor. These prognostics are however very uncertain ; and when the whole of the meteorological variations, at the times when the Globe has been the most agitated, are called to mind, it is found, that violent shocks take place equally in dry and in wet weather ; when the coolest winds blow, or during a dead and suffocating calm. From the great number of earthquakes,

\* Arist. Meteor., Lib. ii, (ed. Duval., t. i, p. 798). Seneca, Nat. Quæst., lib. vi, c. 12.

which I have witnessed to the north and south of the equator; on the continent, and in the basin of the seas; on the coasts, and at 2500 toises height; it appears to me, that the oscillations are generally very independent of the previous state of the atmosphere. This opinion is embraced by a number of enlightened persons, who inhabit the Spanish colonies; and whose experience extends, if not over a greater space of the Globe, at least to a greater number of years, than mine. On the contrary, in parts of Europe where earthquakes are rare compared to America, natural philosophers are inclined to admit an intimate connection between the undulations of the ground, and certain meteors, which accidentally take place at the same epocha. In Italy, for instance, the sirocco and earthquakes are suspected to have some connection; and at London, the frequency of falling stars, and those southern lights\*, which

\* Philos. Transact., vol. xlv, p. 642, 663, and 743. The appearance of these meteors led two distinguished men of science, nearly at the same time, to adopt theories diametrically opposite to each other. Hales, struck with his experiments on the decomposition of nitrous gas when it comes into contact with atmospheric air, invented a chemical theory, according to which, the earthquake was the effect "of a prompt condensation of sulphurous and nitrous exhalations." *Ib.* p. 678. Stukeley, familiar with Franklin's ideas of the distribution of electricity in the strata of the atmosphere, con-

have since been often observed by Mr. Dalton, were considered as the forerunners of those shocks, which were felt from 1748 to 1756.

On the days when the earth is shaken by violent shocks, the regularity of the horary variations of the barometer is not disturbed under the tropics. I have verified this observation at Cumana, at Lima, and at Riobamba ; and it is so much the more worthy of fixing the attention of natural philosophers, as at St. Domingo, at the town of Cape François, it is asserted, that a water barometer \* was observed to sink two inches and a half immediately before the earthquake of 1770. In the same manner it is related, that, at the destruction of Oran, a druggist fled with his family, because, observing accidentally, a few minutes before the earthquake, the height of the

sidered the oscillatory motion of the surface of the Globe as the effect of an electric shock propagated from the air to the earth. *Ib.* p. 642. Each of these theories admitted the existence of a large black cloud separating strata of air unequally charged with electricity, or with nitrous vapours ; and this cloud was seen at London at the moment of the first shocks. I mention these reveries, to show to what errors we expose ourselves in geology and physics, when, instead of taking into view the whole of the phenomena that occur, we suffer our attention to be arrested by accidental circumstances.

\* Currejollès, in the *Journal de Phys.*, tom. liv. p. 106. This depression answers only to two lines of mercury. The barometer remained motionless at Pignerol, in April, 1808. (*Ibid.* t. lxxvii, p. 292.)



mercury in his barometer, he perceived, that the column sunk in an extraordinary manner. I know not whether we can give credit to this assertion; but as it is nearly impossible to examine the variations of the weight of the atmosphere during the shocks, we must be satisfied in observing the barometer before or after these phenomena have taken place. In the temperate zone, the aurora borealis does not always modify the variation of the needle, and the intensity of the magnetic forces\*. Perhaps also earthquakes do not act constantly in the same manner on the air that surrounds us.

We can scarcely doubt, that the earth, when opened and agitated by shocks, spreads occasionally gaseous emanations through the atmosphere, in places remote from the mouths of volcanoes not extinct. At Cumana, as we have already observed, flames and vapors mixed with sulphurous acid spring up from the most arid soil. In other parts of the same province, the earth ejects water and petroleum. At Riobamba a muddy and inflammable mass, which is called *moya*, issues from crevices that close again, and

\* I had an opportunity of observing, conjointly with Mr. Oltmanns at Berlin, on the night of the 20th of December, 1806, a change of magnetic intensity. The point of convergence of the rays of the aurora borealis was determined astronomically by the azimuth of a star. (Gilbert's Annalen, 1811, p. 274.)

accumulates into elevated hills. At seven leagues from Lisbon, near Colares, during the terrible earthquake of the first of November, 1755, flames and a column of thick smoke were seen to issue from the flanks of the rocks of Alvidras, and, according to some witnesses, from the bosom of the sea \*. This smoke lasted several days, and it was the more abundant in proportion as the subterraneous noise, which accompanied the shocks, was louder.

Elastic fluids thrown into the atmosphere may act locally on the barometer, not by their mass, which is very small, compared to the mass of the atmosphere; but because, at the moment of the great explosions, an ascending current is probably formed, which diminishes the pressure of the air. I am inclined to think, that in the greater part of earthquakes nothing escapes from the agitated earth; and that, where gaseous emanations and vapours take place, they oftener accompany, or follow, than precede the shocks. This last circumstance explains a fact, which seems indubitable, I mean that mysterious influence, in equinoctial America, of earthquakes on the climate, and on the order of the dry and rainy seasons. If the earth generally act on the air only at the moment of the shocks, we can conceive why it is so rare, that a sensible me

\* Phil. Trans., t. xlix, p. 414.

teorological change becomes the presage of these great revolutions of nature.

The hypothesis according to which, in the earthquakes of Cumana, elastic fluids tend to escape from the surface of the soil, seems confirmed by the observation of the dreadful noise, which is heard during the shocks at the borders of the wells in the *plain of Charas*. Water and sand are sometimes thrown out twenty feet high. Similar phenomena have not escaped the observation of the ancients, who inhabited parts of Greece and Asia Minor abounding with caverns, crevices, and subterraneous rivers. Nature, in it's uniform progress, every where suggests the same ideas of the causes of earthquakes, and the means by which man, forgetting the measure of his strength, pretends to diminish the effect of the subterraneous explosions. What a great Roman naturalist has said of the utility of wells and caverns\* is repeated in the New World

\* In puteis est remedium, quale et crebri specus præbent : conceptum enim spiritum exhalant : quod in certis notatur oppidis, quæ minus quatiuntur, crebris ad eluvium cuniculis cavata. Plin. Lib. ii, c. 82. (ed. Par. 1725, t. i, p. 112.) Even at present, in the capital of St. Domingo, wells are considered as diminishing the violence of the shocks. I shall observe on this occasion, that the theory of earthquakes, given by Seneca (Nat. Quæst., Lib. vi, c. 4—31), contains the germe of every thing that has been said in our times on the action of the elastic vapors confined in the interior of the Globe. (Compare Michell, in the Phil. Trans., t. li, p. 566—

by the most ignorant Indians of Quito, when they show travellers the *guaicos*, or crevices of Pichincha.

The subterraneous noise, so frequent during earthquakes, is generally not in the ratio of the strength of the shocks. At Cumana it constantly precedes them, while at Quito, and for a short time past at Caraccas, and in the West India Islands, a noise like the discharge of a battery was heard, a long time after the shocks had ceased. A third kind of phenomenon, the most remarkable of the whole, is the rolling of those subterraneous thunders, which last several months, without being accompanied by the least oscillating motion of the ground\*.

In every country subject to earthquakes, the point where, probably by a particular disposition of the stony strata, the effects are the most sensible, is considered as the cause and the focus of the shocks. Thus at Cumana the hill of the castle of St. Antonio, and particularly the eminence on which the convent of St. Francis is

634; and Dr. Young in Rees's New Cyclopedia, Vol. xii, P. 2, art. EARTHQUAKE.

\* The subterraneous thunders (*bramidos y truenos subterráneos*) of Guanaxuato will be described in the course of this work. (Nouv. Esp., t, p. 47.) The phenomenon of a noise without shocks had already been observed by the ancients. (Aristot. Meteor. lib. ii, ed. Duval, p. 802. Plin. lib. ii, c. 80.)

placed, are believed to contain an enormous quantity of sulphur, and other inflammable matter. We forget, that the rapidity with which the undulations are propagated to great distances, even across the basin of the ocean, proves, that the centre of action is very remote from the surface of the Globe. From this same cause no doubt earthquakes are not restrained to certain species of rocks, as some naturalists pretend, but all are fitted to propagate the movement. In order to keep within the limits of my own experience, I shall here cite the granites of Lima and Acapulco; the gneiss of Caraccas; the mica-slate of the peninsula of Araya; the primitive thonschiefer of Tepecuacuilco, in Mexico; the secondary limestones of the Apennines, Spain, and New Andalusia; and finally the trappean porphyries of the provinces of Quito, and Popayan \*. In these different places the ground is frequently agitated by the most violent shocks; but sometimes, in the same rock, the superior strata form invincible obstacles to the propagation of the motion. Thus, in the mines of Saxony †, we have seen workmen hasten up af-

\* I might have added to the list of secondary rocks the gypsum of the newest formation, for instance that of Montmartre placed on a marine calcareous rock, which is posterior to the chalk. See the *Mém. de l'Académie*, t. i, p. 341, on the earthquake felt at Paris, and in it's environs, in 1681.

† At Marienburgh in the Erzgebuerge.



frighted by oscillations, which were not felt at the surface of the ground.

If, in regions the most remote from each other, primitive, secondary, and volcanic rocks, share equally in the convulsive movements of the Globe; we cannot but admire also, that, in ground of little extent, certain classes of rocks oppose themselves to the propagation of the shocks. At Cumana, for instance, before the great catastrophe of 1797, the earthquakes were felt only along the southern and calcareous coast of the gulf of Cariaco, as far as the town of this name; while in the peninsula of Araya, and at the village of Maniquarez, the ground did not partake of the same agitation. The inhabitants of this northern coast, which is composed of mica-slate, built their huts on a motionless earth; a gulf three or four thousand toises in breadth separated them from a plain covered with ruins, and overturned by earthquakes. This security, founded on the experience of several ages, has vanished; and since the 14th of December, 1797, new communications appear to have been opened in the interior of the Globe. At present the peninsula of Araya is not merely subject to the agitations of the soil of Cumana, the promontory of mica-slate is become in its turn a particular centre of the movements. The earth is sometimes strongly shaken at the village of Maniquarez, when on the coast of Cumana

the inhabitants enjoy the most perfect tranquillity. The gulf of Cariaco nevertheless is only sixty or eighty fathoms deep.

It has been thought from observations made both on the continent and in the islands, that the western and southern coasts are most exposed to shocks \*. This observation is connected with the ideas which geologists have long formed of the position of the high chains of mountains, and the direction of their steepest declivities : the existence of the Cordillera of Caraccas, and the frequency of the oscillations on the eastern and northern coast of Terra Firma, in the gulf of Paria, at Carupano, at Cariaco, and at Cumana, are proofs of the uncertainty of this opinion.

In New Andalusia, as well as in Chili and Peru, the shocks follow the course of the shore ; and extend but little inland. This circumstance, as we shall soon find, indicates an intimate connection between the causes that produce earthquakes and volcanic eruptions. If the earth was most agitated on the coasts, because they are the lowest part of the land, why should not the oscillations be equally strong and frequent on those vast savannahs or meadows †, which

\* Courrejolles, in the Journ. de Phys. t. liv, p. 104.

† The *Llanos* of Cumana, of New Barcelona, of Calabozo, of Apura, and of Meta.

are scarcely eight or ten toises above the level of the ocean?

The earthquakes of Cumana \* are connected with those of the West India islands ; and it has even been suspected, that they have some connection with the volcanic phenomena of the Cordilleras of the Andes. On the 4th of November, 1797, the soil of the province of Quito underwent such a destructive commotion, that, notwithstanding the extreme feebleness of the population of that country, near 40000 natives perished, buried under the ruins of their houses, swallowed up in the crevices, or drowned in lakes that were suddenly formed. At the same period, the inhabitants of the eastern Antilles were alarmed by shocks, which continued during eight months, when the volcano of Guadaloupe threw out pumice stones, ashes, and gusts of sulphureous vapors. This eruption of the 27th of September, during which very long-continued subterraneous noises were heard †, was followed

\* See my Geological Table of South America, Journ. de Physique, t. liii, p. 58.

† Report made to the generals Victor Hugues and Lebas, by Amie, Peyre, Hapel, Fontelliau, and Codé, appointed to examine the situation of the volcano of Basse-Terre, and the effects that had taken place in the night, from the seventh to the eighth of Vendemiaire, in the year 6 : p. 46. This narrative of a journey to the top of the volcano, contains several curious observations ; it was printed at Guadaloupe in 1798.

on the 14th of December by the great earthquake of Cumana. Another volcano of the West India islands, that of St. Vincents\*, has lately given a fresh instance of these extraordinary connections. This volcano had not emitted flames since 1718, when they burst forth anew, in 1812. The total ruin of the city of Caraccas † preceded this explosion thirty-five days, and violent oscillations of the ground were felt, both in the islands, and on the coasts of Terra Firma.

It has long been remarked, that the effects of great earthquakes extend much farther than the phenomena arising from burning volcanoes. In studying the physical revolutions of Italy, carefully examining the series of the eruptions of Vesuvius and Etna, we can scarcely recognize, notwithstanding the proximity of these mountains, any traces of a simultaneous action. It is on the contrary doubtless, that at the period of the last and preceding destruction of Lisbon ‡, the

\* Letter from Mr. Hamilton to Sir Joseph Banks, 1813. The eruption began on the 30th of April, 1812; it was preceded by repeated earthquakes, during eleven months. (Phil. Trans. for 1785, p. 16.)

† The 26th of March, 1812.

‡ The 1st of November 1755, and 31st of March 1761. During the first of these three earthquakes, the ocean inundated, in Europe, the coasts of Sweden, England, and Spain; in America, the islands of Antigua, Barbadoes, and Martinico. At Barbadoes, where the tides rise only from 24 to 28

sea was violently agitated even as far as the New World, for instance, at the island of Barba-

inches, the water rose twenty feet in Carlisle Bay. It became at the same time "as black as ink;" because, without doubt, it was mixed with the petroleum, or asphaltum, which abounds at the bottom of the sea, as well on the coasts of the gulf of Cariaco, as near the island of Trinidad. In the West Indies, and in several lakes of Switzerland, this extraordinary motion of the waters was observed six hours after the first shock that was felt at Lisbon. (Phil. Trans., vol. xlix, p. 403, 410, 544, 688; *ibid.*, vol. lii, p. 424.) At Cadiz a mountain of water sixty feet high was seen eight miles distant at sea; this mass threw itself impetuously on the coasts, and beat down a great number of edifices; like the wave fourscore and four feet high, which, on the 9th of June, 1586, at the time of the great earthquake at Lima, covered the port of Callao. (Acosta, *Hist. natural de las Indias*, ed. de 1591, p. 123.) In North America, on Lake Ontario, strong agitations of the water were observed, from the month of October 1755. These phenomena are proofs of subterraneous communications at enormous distances. On comparing the epochas of the great catastrophes of Lima and Guatimala, which generally succeed each other at long intervals, it has sometimes been thought, that the effect of an action slowly propagating itself along the Cordilleras, sometimes from north to south, at other times from south to north, may be perceived. (Cosme Bueno, *Descripcion del Peru*, ed. de Lima, p. 67.) The following are four of these remarkable epochas.

MEXICO.	PERU.
(Lat. 13° 32' north.)	(Lat. 12° 2' south.)
30th of Nov. 1577.	17th of June, 1578.
4th of March, 1679.	17th of June, 1678.
12th of Feb. 1689.	10th of Oct. 1688.
27th of Sept. 1717.	8th of Feb. 1716.



does, more than twelve hundred leagues distant from the coast of Portugal.

Several facts tend to prove, that the causes which produce earthquakes have a near connection with those that act in volcanic eruptions \*. We learnt at Pasto, that the column of black and thick smoke, which, in 1797, issued for several months from the volcano near this shore, disappeared at the very hour, when, sixty leagues to the south, the towns of Riobamba, Hambato, and Tacunga, were overturned by an enormous shock. When, in the interior of a burning crater, we are seated near those hillocks formed by ejections of scorix and ashes, we feel the motion

When the shocks are not simultaneous, or do not follow at short intervals, great doubts may be entertained with respect to the pretended communication of the movement.

\* The connection of these causes, already known to the ancients, excited fresh attention at the period of the discovery of America. (Acosta, p. 121.) This discovery not only offered new productions to the curiosity of men, it gave also extent to their ideas on physical geography, on the varieties of the human species, and the migrations of nations. It is impossible to read the first narratives of the Spanish travellers, especially those of the Jesuit Acosta, without perceiving with surprise the influence which the aspect of a great continent, the study of extraordinary appearances of nature, and an intercourse with men of different races, have exerted on the progress of knowledge in Europe. The germe of a great number of physical truths is found in the works of the sixteenth century; and this germe would have fructified, had it not been crushed by fanaticism and superstition.

of the ground several seconds before each partial eruption takes place. We observed this phenomenon at Vesuvius in 1805, while the mountain threw out scorïæ at a white heat ; we were witnesses of it in 1802, on the brink of the immense crater of Pichincha, from which nevertheless at that time clouds of sulphureous acid vapours only issued.

Every thing in earthquakes seems to indicate the action of elastic fluids seeking an outlet to spread themselves in the atmosphere. Often, on the coasts of the South Sea, the action is almost instantaneously communicated from Chili to the gulf of Guayaquil, a distance of six hundred leagues ; and, what is very remarkable, the shocks appear to be so much the stronger, as the country is more distant from burning volcanoes. The granitic mountains of Calabria, covered with very recent breccia, the calcareous chain of the Apennines, the country of Pignerol, the coasts of Portugal and Greece, those of Peru and Terra Firma, afford striking proofs of this assertion \*. The Globe, it may be said, is agitated with greater force, in proportion as the surface has a smaller number of funnels communicating with the caverns of the interior. At Naples and at Messina, at the foot of Cotopaxi and of Tunguragua, earthquakes are dreaded

\* Fleuriau de Bellevue, Journ. de Phys., t. lxii, p. 261.

only when vapours and flames do not issue from the crater. In the kingdom of Quito, the great catastrophe of Riobamba, which we have before mentioned, has led several well-informed persons to think, that this unfortunate country would be less often desolate, if the subterraneous fire should break the porphyritic dome of Chimborazo; and if this colossal mountain should become a burning volcano. At all times analogous facts have led to the same hypothesis. The Greeks, who, like ourselves, attributed the oscillations of the ground to the tension of elastic fluids, cited in favour of their opinion the total cessation of the shocks at the island of Eubœa, by the opening of a crevice in the Lelantine plain \*.

We have endeavoured to collect at the end of this chapter the general phenomena of earthquakes under different climates. We have shown, that subterraneous vapours are subjected to laws as uniform as the mixture of gaseous fluids, which constitutes our atmosphere. We have abstained from all discussion of the nature of the chemical agents, which are the causes of the great derangements that the surface of the earth undergoes from time to time.

\* The shocks ceased only when a crevice, which ejected a "river of fiery mud," opened in the plain of Lelantum, near Chalcis. Strabo, lib. 1, ed. Oxon., 1807, t. i, p. 85. (See also the translation by M. du Theil. t. i, p. 137, note 4.)

It is sufficient here to observe, that these causes are concealed at immense depths ; and that we must seek them in the rocks which we call primitive, perhaps even below the earthy and oxidized crust of the Globe, in the abysses that contain the metalloidal bases of silex, lime, soda, and potash.

The phenomena of volcanoes, and those of earthquakes, have been considered of late as the effects of voltaic electricity, developed by a particular disposition of heterogeneous strata. It cannot be denied, that often, when violent shocks succeed each other in the space of a few hours, the electricity of the air \* sensibly increases at the instant the ground is most agitated ; but in order to explain this phenomenon, it is unnecessary to recur to an hypothesis, which is in direct contradiction to every thing that has hitherto been observed respecting the structure of our planet, and the disposition of it's strata.

\* See the electroscopical experiments made in Piedmont, in the valleys of Pelis and Clusson, in 1808. *Journal de Phys.*, t. 67, p. 292.

## CHAPTER V.

*Peninsula of Araya.—Salt-Marshes.—Ruins of the Castle of San Giacomo.*

THE first weeks of our abode at Cumana were employed in verifying our instruments, in herbalizing in the neighbouring fields, and in examining the traces of the earthquake of the 14th of December, 1797. Overpowered at once by a great number of objects, we were somewhat embarrassed to lay down a regular plan of study and observation. If every thing around us was fitted to inspire us with the most lively interest, our physical and astronomical instruments in their turns excited strongly the curiosity of the inhabitants. We were distracted by frequent visits; and in order not to dissatisfy persons, who appeared so happy to see the spots of the Moon through Dollond's telescope, the absorption of two gazes in a eudiometrical tube, or the effects of galvanism on the motions of a frog, we were obliged to answer questions often obscure, and repeat for whole hours the same experiments.

These scenes were renewed for the space of



five years, every time that we took up our abode in a place where it was understood, that we were in possession of microscopes, telescopes, and electrical apparatus. They were in general so much the more fatiguing, as the person who visited us had confused notions of astronomy and physics ; two sciences, which in the Spanish colonies are designated under the singular name of the new philosophy, *nueva filosofia*. The half-scientific looked on us with a sort of disdain, when they learnt that we had not brought in our collection of books the *Spectacle de la Nature* by Abbé Pluche, the *Cours de Physique* of Sigaud la Fond, or the Dictionary of Valmont de Bomare. These three works, and the *Traité d'Economie politique* of Baron Bielfeld, are the foreign works most known and esteemed in Spanish America, from Caraccas and Chili to Guatimala and the north of Mexico. No one is thought learned, who cannot quote their translations ; and it is only in the great capitals, at Lima, at Santa Fe de Bogota, and at Mexico, that the names of Haller, Cavendish, and Lavoisier, begin to take the place of those, that have enjoyed popular celebrity for these fifty years past.

The curiosity excited respecting the phenomena of the heavens, and various objects of the natural sciences, takes a very different character among anciently civilized nations, and among

those who have made but little progress in the unfolding of their intellectual faculties. Each of them exhibits in the highest classes of society frequent examples of persons unacquainted with science ; but in the colonies, and among new people, curiosity, far from being idle or transient, arises from an ardent desire of instruction, and discovers itself with an ingenuousness and simplicity, which in Europe are the characteristics only of youth.

I could not begin a regular course of astronomical observations before the 28th of July, though it was highly important for me to know the longitude given by Berthoud's time-keeper ; but it happened, that in a country, where the sky is constantly clear and serene, no stars appeared for several nights. Every day, two hours after the Sun had passed the meridian, a storm gathered ; and I had great difficulty in obtaining correspondent altitudes of the Sun, though I took three or four sets at different intervals. The chronometrical longitude of Cumana differed only four seconds in time from that which I deduced from the celestial phenomena ; yet our voyage had lasted more than forty days, and during the excursion to the top of the Peak of Teneriffe, the watch had been exposed to great variations of temperature \*.

\* Astron. Observ. vol. i, p. xxiv.

From the whole of the observations \* which I made in 1799 and 1800 it follows, that the latitude of the great square at Cumana is  $10^{\circ} 27' 52''$ , and it's longitude  $66^{\circ} 30' 2''$ . This longitude is founded on the difference of time, on lunar distances, on the eclipse of the Sun on the 28th of October, 1799, and on ten immersions of Jupiter's satellites, compared with observations made in Europe. It differs very little from that which Mr. Fidalgo had obtained before me, but only by mere chronometrical means. The oldest chart which we have of the Continent, that of Don Diego Ribeiro, geographer to the emperor Charles the Fifth, places Cumana in latitude  $9^{\circ} 30'$  †; which differs fifty-eight minutes from the real latitude, and half a degree from that marked by Jefferies in his American Pilot, published in 1794. During three centuries the whole of the coast of Terra Firma has been laid down too far to the south: this has been owing to the current near the island of Trinidad, which sets toward the north, and mariners are led by their dead-reckoning, to think themselves farther south than they really are.

\* Astron. Obs., vol. i, p. 42 to 92.

† According to Herera, latitude  $9^{\circ} 50'$  (Description de las Indias Occid. p. 9). According to the Carte de l'Océan Atlantique, publiée au Dépôt de la Marine en 1792, latitude  $9^{\circ} 52'$ . The chart of Ribeiro is of the year 1529.

On the 17th of August a halo, or luminous circle, round the Moon, fixed the attention of the inhabitants, who considered it as the presage of some violent earthquake: for, according to the physical notions of the people, all extraordinary phenomena are immediately connected with each other. Coloured circles around the Moon are much more rare in the countries of the north, than in Provence, Italy, and Spain. They are seen particularly, and this fact is singular enough, when the sky is clear, and the weather seems to be most fair and settled. Under the torrid zone beautiful prismatic colours appear almost every night, even at the time of the greatest droughts: often in the space of a few minutes they disappear several times, because, without doubt, the superior currents change the state of the floating vapours, by which the light is refracted. I sometimes even observed, between the fifteenth degree of latitude and the equator, small haloes around the planet Venus; the purple, orange, and violet, were distinctly perceived; but I never saw any colours around Sirius, Canopus, or Acherneer.

While the halo was visible at Cumana, the hygrometer noted great humidity; nevertheless the vapors appeared so perfectly in solution, or rather so elastic and uniformly disseminated, that they did not alter the transparency of the atmosphere. The moon arose after a storm of



rain, behind the castle of St. Antonio. As soon as she appeared on the horizon, we distinguished two circles; one large and whitish, forty-four degrees in diameter; the other a small circle of  $1^{\circ} 43'$ , displaying all the colors of the rainbow. The space between the two circles was of the deepest azure. At four degrees height, they disappeared, while the meteorological instruments indicated not the slightest change in the lower regions of the air. This phenomenon had nothing extraordinary, except the great brilliancy of the colors, added to the circumstance, that, according to the measures taken with Ramsden's sextant, the lunar disk was not exactly in the centre of the haloes. Without this actual measurement, we might have thought, that the excentricity was the effect of the projection of the circles on the apparent concavity of the sky\*. The form of the haloes;

\* The 17th of August, 1799: thermometer,  $25^{\circ} 3'$ ; Deluc's hygrometer,  $68^{\circ}$ . The altitude of the Moon being,  $11^{\circ} 8'$ , the horizontal diameter of the little corona was  $1^{\circ} 50'$ , and it's vertical diameter  $1^{\circ} 43'$ . The distance from the centre of the Moon to the upper edge of the small halo was forty-one minutes, and to the lower edge fifty-nine minutes. The whole space between the lunar disk and the extremity of the small halo shone with prismatic colors. The horizontal diameter of the large white halo was  $42^{\circ} 3'$ . When the Moon had attained the altitude of  $37^{\circ} 34'$  above the horizon, the diameter of the greater halo was  $44^{\circ} 10'$ , and the breadth of the milky band  $3^{\circ} 35'$ . The Moon no longer showed any



and the colors of the atmosphere of the tropics enlightened by the Moon, are worthy of new researches on the part of natural philosophers. At Mexico, in extremely fine weather, I have seen large bands \*, having all the colors of the rainbow, spread along the vault of the sky, and converging toward the lunar disk; a curious meteor, which reminds us of that described by Mr. Cotes † in 1716.

If the situation of our house at Cumana was highly favourable for the observation of the stars and meteorological phenomena, it obliged us to be sometimes the witnesses of afflicting

excentricity, and the small halo had only  $1^{\circ} 27'$  diameter. These measures were taken without a telescope, and by bringing with the sextant the edge of the Moon into contact with the very well defined extremities of both haloes. It seemed to me difficult to admit my being deceived nineteen minutes with respect to the excentricity of the Moon: the refraction would have rather diminished than have augmented the extent of the halo toward the lower edge. We must not confound this phenomenon, which belongs to the last strata of the atmosphere, and which is observed in a clear sky without any visible vapors, with those colored circles which are projected on the white clouds driven by the wind, before the lunar disk, and which have only seven or eight hundred toises of absolute height. (See Gibbes Walker Jordan, in Nicholson's Journ., 4to. ed., vol. iv, p. 141; and Newton's Optics, 1722, p. 476.)

\* The night of the 8th of May, 1813.

† Smith's Optics, French translation, 1767, t. i, p. 173, § 109, and p. 121, § 169.

scenes in the day. A part of the great square is surrounded with arcades, above which is one of those long wooden galleries, which are common in warm countries. This was the place where slaves, brought from the coast of Africa, were sold. Of all the European governments Denmark was the first, and for a long time the only power, that abolished the trade ; notwithstanding which, the first negroes we saw exposed for sale had been landed from a Danish slave-ship. What are the duties of humanity, national honour, or the laws of his country, to a man stimulated by the speculations of sordid interest ?

The slaves exposed to sale were young men from fifteen to twenty years of age. Every morning cocoa-nut oil was distributed among them, with which they rubbed their bodies, to give their skin a black polish. The persons who came to purchase examined the teeth of these slaves, to judge of their age and health ; forcing open their mouths as we do those of horses in a market. This degrading custom dates from Africa, as is proved by the faithful picture, which, in one of his dramatic pieces\*, Cervantes, released from his long captivity among the Moors, has drawn of the sale of the Christian slaves at

\* *El Trato de Argel*. Jorn. II. (*Viage al Parnasso*, 1784, p. 316).

Algiers. It is distressing to think, that even at this day there exist European colonists in the West Indies, who mark their slaves with a hot iron, to know them again if they escape. This is the treatment bestowed on those, "who save other men the trouble of sowing, tilling, and reaping, in order to live\*."

The greater the impression which the first sale of negroes made on us, the more we congratulated ourselves on living among a people, and on a continent, where this sight is rare, and where the number of slaves is in general very inconsiderable. The number in 1800 did not exceed six thousand in the two provinces of Cumana and Barcelona, when at the same period the whole population was estimated at one hundred and ten thousand inhabitants. The trade in African slaves, which the Spanish laws have never favoured, is almost nothing on coasts, where the trade in American slaves was carried on in the sixteenth century with a desolating

\* La Bruyère, *Caractères*, Chap. XI. (ed. 1765, p. 303). I wish to cite at length a passage, in which the love of the human species is drawn with force, or rather with noble severity. "We find (under the torrid zone) certain wild animals, male and female, scattered through the country, black, livid, and all over scorched by the Sun, bent to the earth which they dig and turn up with invincible perseverance. They have something like an articulate voice; and, when they stand up on their feet, they exhibit a human face, and in fact these creatures are men."

activity. Macarapan, anciently called Amara-capana, Cumana, Araya, and particularly New Cadiz, built on the islet of Cubagua, might then be considered as commercial establishments to facilitate the trade. Girolamo Benzoni of Milan, who at the age of twenty-two years, had gone over to Terra Firma, took part in some expeditions made in 1542 to the coasts of Bordones, Cariaco, and Paria, to carry off the unfortunate natives. He relates with simplicity, and often with a sensibility not common in the historians of that time, the examples of cruelty, of which he was a witness. He saw the slaves dragged to New Cadiz, to be marked on the forehead and on the arms, and to pay the *quint* to the officers of the crown. From this port the Indians were sent to the island of Hayti\*, or St.

\* “Noi pigliammo dugento e quaranta schiavi fra maschi e femine, piccoli e grandi. Cosa veramente molto compassionevole da vederla la condotta di quelle meschine creature, nude, stanche, stropiate. Le infelici madri con due e tre figliuoli su le spalle e in collo, colme di pianto e di dolore, afflitte, legati tutti da corde e di catene di ferro al collo, alle braccia, e alle mani. Si conducono a Cubagua e tutti si marchiano in faccia e su le braccia con ferro infocato, segnato d'un C; poi gli capitani ne fanno parte a soldati, che gli vendono, e se gli giuocano l'uno con altro. Se paga il quinto delle perle, del oro e dei schiavi a gli ufficiali del Re.” Benzoni, Hist: del Mondo Nuovo, 1565, p. 4, 7, and 9. It was thus that the Phœnicians and Carthaginians formerly sought for slaves in Europe. Heyne, Opuscula, t. iii, p. 63.

Domingo, after having often changed masters, not by way of sale, but because the soldiers played for them at dice.

The first excursion we made was directed toward the peninsula of Araya, and those countries formerly too much celebrated for the slave-trade and pearl-fishery. We embarked on the Rio Manzanares, near the Indian suburb, on the 19th of August, about two in the morning. The principal object of this excursion was to see the ruins of the castle of Araya, to examine the salt-works, and make a few geological observations on the mountains, that form the narrow peninsula of Maniquarez. The night was delightfully cool; swarms of phosphorescent insects\* glittered in the air, and over a soil covered with sesuvium, and groves of mimosa, that bordered the river. We know how common the glow-worm † is in Italy, and in all the south of Europe; but the picturesque effect it produces cannot be compared to those innumerable, scattered, and moving lights, that embellish the nights of the torrid zone, and seem to repeat on the earth, along the vast extent of the savannahs, the spectacle of the starry vault of the sky.

When, on descending the river, we drew near

\* *Elater noctilucus*.

† *Lampyris italica*, l. *noctiluca*.



some plantations, or *charas*, we saw bonfires kindled by the negroes ; a light and undulating smoke rose to the tops of the palm trees, and gave a reddish color to the disk of the Moon. It was on a Sunday night, and the slaves were dancing to the noisy and monotonous music of the guitar. The people of Africa, of negro race, have an inexhaustible store of activity and gaiety in their character. After having passed through the painful labours of the week, the slaves, on days of festival, prefer the sounds of music, and the dance, to listless sleep. Let us not blame this mixture of carelessness and levity, which softens the bitterness of a life full of pains and sorrows !

The bark in which we passed the Gulf of Cariaco was very spacious. Large skins of the jaguar, or American tiger, were spread for our repose during the night. We had scarcely been two months under the torrid zone, and our organs were already become so sensible to the smallest variation of temperature, that the cold prevented us from sleeping ; while to our surprise we saw that the centigrade thermometer was as high as  $21.8^{\circ}$ . This observation, well known to those who have lived a long time in the Indies, is worthy the attention of physiologists. Bouguer relates, that, when he reached the summit of Montagne Pelée, in the island of Martinico, he and his companion shook with

cold, though the heat was above 21·5 degrees \*. In reading the interesting narrative of Captain Bligh, who, in consequence of a mutiny on board the *Bounty*, was forced to make a voyage of twelve hundred leagues in an open boat, we see, that this navigator, in the tenth and twelfth degrees of south latitude, suffered much more from cold than from hunger †. During our abode at Guayaquil, in the month of January, 1803, we observed, that the natives covered themselves, and complained of the cold, when the thermometer sunk to 23·8°, while the heat appeared suffocating at 30·5°. Six or seven degrees

\* *Figure de la Terre*, p. liv. - The height of this summit is 736 toises, according to Dupuget ; and 666 toises, according to Mr. Le Blond. This elevation consequently is not considerable enough, to cause a feeling of cold, as at Chimborazo and Pichincha, by the smaller quantity of oxygen inhaled by the lungs from a dilated air. If the barometer, (at 16·2° temperature) keeps at the top of the Montagne Pelée at 24 inches 2 lines (*Le Blond, Voy. aux Antilles et dans l'Amérique Méridionale*, t. i, p. 87), the absolute height of this point is 660 toises, according to the rule of Mr. Laplace; supposing at the level of the sea the height of the mercury 28 inches 1 line, and the thermometer at twenty-five degrees.

† Bligh's *Voyage to the South Sea*, translated by Soulés, p. 265 and 316. The crew in the boat were often wet by the waves ; but we know, that in this latitude, the temperature of the sea water cannot be below twenty-three degrees, and that the cold produced by evaporation is inconsiderable during the night, when the temperature of the air seldom exceeds twenty-five degrees.

were sufficient to cause the opposite sensations of cold and heat, because on these coasts of the South Sea the habitual temperature of the atmosphere is twenty-eight degrees. The humidity, which modifies the conducting power of the air for heat, contributes greatly to these impressions. In the port of Guayaquil, as everywhere else in the low regions of the torrid zone, the weather grows cool only from storms of rain: and I have observed, that, when the thermometer sinks to  $23.8^{\circ}$ , De Luc's hygrometer keeps up to fifty and fifty-two degrees \*; it is, on the contrary, at thirty-seven degrees † in a temperature of  $30.5^{\circ}$ . At Cumana, in very heavy showers, we hear in the streets; *que hielo! estoy emparamado* ‡; though the thermometer exposed

\*  $85.8^{\circ}$  and  $86.4^{\circ}$  of Saussure's hygrometer.

†  $73^{\circ}$  Saussure.

‡ “What an icy cold! I shiver as if I was on the top of the mountains.” The provincial word *emparamarse* can be translated only by a very long periphrasis. *Paramo*, in Peruvian *puna*, is a denomination found on all the maps of Spanish America. In the colonies it signifies neither a desert nor a heath, but a mountainous place covered with stunted trees, exposed to the winds, and in which a damp cold perpetually reigns. Under the torrid zone, the paramoes are generally from one thousand six hundred to two thousand toises high. Snow often falls on them, but it remains only a few hours; for we must not confound, as geographers often do, the words *paramo* and *puna* with that of *nevado*, in Peruvian *ritticapa*, a mountain which enters into the limits of the per-

to the rain sinks only to  $21.5^{\circ}$ . From the who of these observations it follows, that between the tropics, in plains where the temperature of the air is in the day time almost invariably above twenty-seven degrees, warmer clothing during the night is requisite, whenever in a damp air the thermometer sinks four or five degrees.

We landed, about eight in the morning, at the point of Araya, near the new salt-works. A solitary house stands in a plain destitute of vegetation, near a battery of three guns, which is the only defence of this coast, since the destruction of the fort of St. James's. The inspector of the salt-works passes his life in a hammock, whence he issues his orders to the workmen; a boat belonging to the king (*la lancha del re*) brings him every week his provision from Cumana. It is surprising that a salt-work, which formerly excited the jealousy of

petual snows. These notions are highly interesting to geology, and the geography of plants; because, in countries where no height has been measured, we may form an exact idea of the *least height* to which the Cordilleras rise, in looking into the map for the words *paramo* and *nevado*. As the *paramoes* are almost continually enveloped in a cold and thick fog, the people say, at Santa Fé, and at Mexico, *cae un paramito*, when a thick small rain falls, and the temperature of the air sinks considerably. From *paramo* has been made *emparamarse*, to be as cold as if we were on the ridge of the Andes.

the English, Dutch, and other maritime powers, has not given rise to a village, or even a farm; a few huts only of poor Indian fishermen are found at the extremity of the point of Araya.

We see at the same time, from this spot, the islet of Cubagua, the lofty hills of Margaretta, the ruins of the castle of St. Jago, the Cerro de la Vela, and the calcareous chain of the Bergantin, which bounds the horizon toward the south. I availed myself of this view, to take the angles between these different points, from a basis of four hundred toises, which I measured between the battery and the hill called the *Penna*. As the Cerro de la Vela, Bergantin, and the castle of St. Antonio at Cumana, are equally visible from the Punta Arenas, situate to the west of the village of Maniquarez, the same objects were employed for an approximate determination of the respective positions of several points, which are laid down in the mineralogical chart of the peninsula of Araya. It follows from these data, that the mere of the old salt-works is nearly in  $10^{\circ} 33'$ . The difference of longitude between Cumana and the new salt-works is, according to Mr. Fidalgo,  $5' 34''$ . I found the same difference by the time-keeper\*. The horary angles were exact to three or four seconds nearly; but I have

\* Astron. Observ. vol. i, p. 6, No. 17.



no confidence in the chronometrical result, because the difference of time amounted only to a few seconds, and the gain of the watch on mean time at Cumana could not be verified immediately after my return, but only four days later.

The abundance of salt \* contained in the peninsula of Araya was already known to Alonzo Ninno †, when, following the steps of Columbus, Ojeda, and Amerigo Vespucci, he visited these countries in 1499. Though of all the people on the Globe the natives of America are those who consume the least salt, because they scarcely eat any thing but vegetables, it nevertheless appears, that the Guayquerias already dug into the clayey and muriatiferous soil of *Punta Arenas*. Even the brine-pits, which are now called *new*, and which are situate at the extremity of Cape Araya, had been worked at very early periods. The Spaniards settled at first at Cubagua, and soon after on the coasts of Cumana, worked from the beginning of the sixteenth century the salt marshes, which stretch away in the form of a mere to the north of Cerro de la Vela. As at that period the peninsula of Araya had no settled population, the Dutch availed themselves of the natural riches of a soil, which appeared a property common to all nations. In our days, each

\* Muriat of soda.

† Caulin, *Hist. chorografica*, p. 123.

colony has it's own salt-works and navigation is so much improved, that the merchants of Cadiz can send at small expence salt from Spain and Portugal, to the southern hemisphere, a distance of 1900 leagues, to cure meat at Monte Video and Buenos Ayres. These advantages were unknown at the time of the conquest ; colonial industry had then made so little progress, that the salt of Araya was carried at great expence to the West India islands, Carthagena, and Portobello \*. In 1605, the court of Madrid sent armed ships to Punta Araya, with orders to station themselves there, and expel the Dutch by force of arms. The Dutch, however, continued to carry on a contraband trade in salt till, in 1622, a fort was built near the salt-works, that afterward became celebrated under the name of the Castillo de Santiago, or of the Real Fuerza de Araya. The great salt-marshes are laid down on the oldest Spanish maps, sometimes as a bay, and at other times as a mere. Laet, who wrote his *Orbis Novus* in 1633, and who had some excellent notions respecting these coasts, expressly states, that the mere was separated from the sea by an isthmus above the level of high water. In 1726, an extraordinary event destroyed the salt-works of Araya, and rendered the fort, the con-

\* MSS. of the archives of Cumana. (*Informes hechos sobre la Salina nueva.*)

struction of which had cost more than a million of piastres, useless. An impetuous hurricane took place, which was a very rare phenomenon in these regions, where the sea is in general as calm as the water in our large rivers. The waves overflowed the land to a great extent; and by the effect of this irruption of the ocean the salt-lake was converted into a gulf several miles in length. Since this period, artificial reservoirs, or pits, (*vasets*) have been formed, to the north of the range of hills which separates the castle from the north coast of the peninsula.

The consumption of salt amounted in 1799 and 1800, in the two provinces of Cumana \* and Barcelona, to nine or ten thousand *fanegas*, each.

\* At the period of my voyage the government of Cumana comprehended the two provinces of New Andalusia and New Barcelona. The words *province* and *gobierno*, or *government*, of Cumana, are consequently not synonymous. A Catalan, Juan de Urpin, who had been by turns a canon, doctor of laws, counsellor at law in St. Domingo, and private soldier in the castle of Araya, founded, in 1636, the city of New Barcelona, and attempted to give the name of New Catalonia (*Nueva Cathalunna*) to the province, of which this newly constructed city became the capital. This attempt was fruitless; and it is from the capital that the whole province took its name. Since my departure from America, it has been raised to the rank of a *Gobierno*. In New Andalusia, the Indian name of Cumana has prevailed over those of *Nueva Toledo* and *Nueva Cordoba*, which we find on the maps of the seventeenth century.

sixteen *arrobas*, or four hundred weight. This consumption is very considerable, and gives, if we deduct from the total population fifty thousand Indians, who eat very little salt, sixty pounds for each person. In France, according to Mr. Necker, twelve or fourteen pounds only are reckoned; and this difference must be attributed to the quantity of salt employed in curing meat. Salt beef, called *tasajo*, is the most important article of export from Barcelona. Of nine or ten thousand *fanegas* furnished by the two provinces united, three thousand only are produced by the salt works of Araya; the rest is extracted from the sea-water at the Morro of Barcelona, at Pozuelos, at Piritu, and in the Golfo Triste. In Mexico, the salt-lake of Pénnon Blanco alone furnishes yearly more than two hundred and fifty thousand *fanegas* of unpurified salt \*.

The province of Caraccas possesses fine salt-works at *Los Roques*; that which formerly existed at the small island of *Tortuga*, where the soil is strongly impregnated with muriat of soda, was destroyed by order of the Spanish government. A canal was made, by which the sea has free access to the salt-marshes. Foreign nations, who have colonies in the West Indies, frequented this uninhabited island; and the court

\* New Spain, vol. ii, p. 562 and 595.



of Madrid, from views of suspicious policy, was apprehensive, that the salt-works of Tortuga would have given rise to settlements, by means of which an illicit trade would have been carried on with Terra Firma.

The royal administration of the salt-works of Araya dates only from the year 1792. Before that period they were in the hands of Indian fishermen, who manufactured salt at their pleasure, and sold it, paying the government the moderate sum of three hundred piastres. The price of the fanega was then four reals\*; but the salt was extremely impure, gray, mixed with earthy particles, and surcharged with muriat and sulphat of magnesia. As the manufacture or labor of the salt-makers was also carried on in the most irregular manner, salt was often wanted for curing meat and fish; a circumstance that has a powerful influence in these countries on the progress of industry, as the lower class of people and the slaves live on fish, and a small portion of *tasajo*. Since the province of Cumana has become dependant on the intendancy of Caraccas, the sale of salt is under the excise; and the *fanega*, which the Guayquerias sold at

\* In this narrative, as well as in the Political Essay on New Spain, all the prices are reckoned in piastres, and silver reals (*reales de plata*). Eight of these reals are equivalent to a piastre, or one hundred and five sous, French money [4s. 4½d. English]. Nouv. Esp. vol. ii, p. 519, 616, and 866.



half a piastre, costs a piastre and a half\*. This augmentation of price is slightly compensated by a greater purity of the salt, and by the facility with which the fishermen and farmers can procure it in abundance during the whole year. The salt-works of Araya yielded the treasury in 1799 a clear income of eight thousand piastres.

From these statistical accounts it results, that the manufacture of salt is of no great importance, considered as a branch of industry. It is more worthy our attention on account of the nature of the soil, which contains the salt-marshes. In order to have a clear idea of the geological connection of this muriatiferous soil with the rocks of more ancient formation, we shall take a general view of the neighbouring mountains of Cumana, and those of the peninsula of Araya, and the island of Margareta.

Three great parallel chains extend themselves from east to west. The two most northerly chains are primitive, and contain the mica-slates of Macanao, and the valley of San Juan, of Maniquarez, and of Chuparipari. These we shall distinguish by the names of *Cordillera of the island of Margareta*, and *Cordillera of Araya*.

\* The fanega is sold to those Indians and fishermen who do not pay the duties (*derechos reales*), at Punta Araya for six, at Cumana for eight reals. The prices to the other tribes are, at Araya ten, at Cumana twelve reals.

The third chain, the most southerly of the whole, the *Cordillera of Bergantin* and of *Cocollar*, contains rocks only of secondary formation; and, what is remarkable enough, though analogous to the geological constitution of the Alps to the west of St. Gothard, the primitive chain is much less elevated than that which was composed of secondary rocks \*. The sea has separated the two northern Cordilleras, those of the island of Margareta, and the peninsula of Araya; and the small islands of Coche and of Cubagua, are remnants of the land that was submerged. Farther to the south, the vast gulf of Cariaco stretches away, like a longitudinal valley formed by the irruption of the ocean, between the two links of Araya and Cocollar, between the mica-slates and the Alpine limestones. We shall soon see, that the direction of the strata, very regular in the first of these rocks, is not quite parallel to the general direction of the gulf. In the high Alps of Europe, the great longitudi-

\* In New Andalusia, the *Cordillera of Cocollar* no where contains primitive rocks. If these rocks form the nucleus of this link, and rise above the level of the neighbouring plains, which is scarcely probable, we must suppose, that they are all covered with lime-stone and sand-stone. In the Swiss Alps, on the contrary, the link which is designated under the too vague denomination of lateral and calcareous link, contains primitive rocks, which, according to the valuable observations of Escher and Leopold von Buch, are often visible to the height of eight hundred or a thousand toises.

nal valley of the Rhone also sometimes cuts \* at an oblique angle the calcareous banks in which it has been excavated.

The two parallel links of Araya and Cocollar were connected, to the east of the town of Cariaco, between the lakes of Campoma, and Putaquao, by a kind of transverse dyke, which bears the name of Cerro de Meapire ; and which in distant times, by resisting the impulse of the waves, has hindered the waters of the gulf of Cariaco from uniting with those of the gulf of Paria. Thus, in Switzerland the central chain, that which passes by the Col de Ferrex, Simplon, St. Gothard, and Spluegen, is connected on the north and the south to two lateral chains, by the mountains of Furca and Maloya. It is pleasing to recall to mind those striking analogies, which are exhibited in both continents by the external structure of the Globe.

The primitive chain of Araya ends abruptly in the meridian of the village of Maniquarez. We shall presently show, that thirty-four leagues to the west it's continuation is found in the gneiss of the *Silla of Caraccas*, and in the granite of *Las Trincheras* : we here confine ourselves to what immediately relates to the environs of Cumana. The western slope of the peninsula of Araya, as well as the plains in the midst of which the cas-

\* Near Sitten (Alpina, t. iv, p. 295. Bernoulli, Geogn. Uebersicht der Schweiz, p. 35—41).

tle of St. Antony rises, is covered with very recent formations of sandstone and clay mixed with gypsum. Perhaps these same formations formerly filled the longitudinal valleys, now occupied by the ocean; and perhaps they favoured the irruption of the waters, by making less resistance than the mica-slates and Alpine limestone. Near Maniquarez a breccia or sandstone with calcareous cement, which might easily be confounded with a real limestone, is placed immediately on the mica-slate; while on the opposite side, near Punta Delgada, this sandstone covers a compact, bluish gray limestone, almost destitute of petrifications, and traversed by small veins of calcareous spar. This last rock is analogous to the limestone of the high Alps\*.

The very recent sand-stone formation of the peninsula of Araya contains, first, near Punta Arenas, a stratified sand-stone, composed of very fine grains, united by a calcareous cement in small quantity; secondly, at the Cerro de la Vela, a schistose sand-stone†, without mica, and passing into slate-clay‡, which accompanies coal; thirdly, on the western side, between Punta Gorda and the ruins of the castle of St. Jago, a breccia composed of an innumerable

\* Alpenkalkstein.

† Sandsteinschiefer.

‡ Schieferthon.

quantity of petrified sea-shells, united by a calcareous cement, in which are mingled grains of quartz ; fourthly, near the point of Barigon, whence the stone employed for building at Cumana is drawn, banks of yellowish white shelly lime-stone, in which are found some scattered grains of quartz ; fifthly, at Pennas Negras, at the top of the *Cerro de la Vela*, a bluish gray compact lime-stone, very tender, almost without petrifications, and covering the schistose sand-stone. However extraordinary this mixture of sand-stone and compact lime-stone \* may appear, we cannot doubt, that these strata belong to one and the same formation. The very recent secondary rocks every where present analogous phenomena ; the *molasse* of the *Pays de Vaud* contains a fetid shelly lime-stone, and the cerite lime-stone of the banks of the Seine is sometimes mixed with sand-stone †.

The strata of calcareous breccia, which can be best examined in going along the rocky coast from Punta Gorda to the castle of Araya, are composed of an infinite number of sea shells, from four to six inches in diameter, and in part well preserved. We find they contain not ammonites, but ampullaires, solens, and terebratulæ. The greater part of these shells are

\* Dichter kalkstein.

† Cuvier and Brongniart, *Geogr. min. des Environs de Paris*, 1811, p. 18, 25, and 135.



mixed; the oysters and pectinities are sometimes arranged in families. The whole are easily detached, and their interior is filled with fossil madrepores and cellapores (*cellulaires*). Formerly, on examining the banks of sand-stone, which at the northern extremity of Punta Araya are frequently bathed by the sea, I had thought, that some univalve shells, resembling the genus *helix*, and mixed with sea bivalve shells, belonged to the fluviatile species \*. This mixture is in fact found † in the lime-stone of very recent formation, that covers the chalk in the basin of Paris; but in order to verify a fact so important, we should have under our eyes the fossile shells of Araya ‡, and examine them anew with that scrupulous exactness, which has been recently followed in this kind of investigation by Messrs. Lamarck, Cuvier, and Brongniart.

We have just mentioned the *mica-slates* of Maniquarez and of Chuparipari; the formation of the *Alpine lime-stone* of Punta Delgada, and of Cocollar; and that of *sand-stone*, of calca-

\* Reuss, Lehrbuch der Geognosie, t. ii, p. 441.

† According to the interesting observation of Mr. Beudan. (See Cuvier and Brongniart, l. c. p. 89.)

‡ Specimens of sand-stone, or shelly breccia of Araya, are found among the geological series, which I sent in 1800 to the collection of the king of Spain at Madrid. There are none of them in the collections which we have deposited at Berlin, and at Paris.

reous breccia, and very recent compact limestone, which is found united at the western extremity of Punta Araya, as well as at the castle of St. Antonio at Cumana. We have now to speak of a fourth formation, which probably reposes \* on the calcareous sandstone of Araya, I mean the *muriatiferous clay*.

This clay, hardened, impregnated with petroleum, and mixed with lamellar and lenticular gypsum, is analogous to the *salzthon*, which in Europe accompanies the sal gem of Berchtesgaden, and in South America † that of Zipaquira. It is generally of a smoke gray color, earthy,

\* I would wish mineralogical travellers, to examine more particularly the Cerro de la Vela. The lime-stone of the Pennas Negras reposes on a slate-clay, mixed with quartzose sand; but there is no proof of the muriatiferous clay of the salt works being of a more ancient formation than this slate-clay, or of it's alternating with banks of sand-stone. No well having been dug in these countries, we can have no information respecting the superposition of the strata. The banks of calcareous sand-stone, which are found at the mouth of the salt lake, and near the fishermen's huts on the coast opposite Cape Macano, appeared to me to lie beneath the muriatiferous clay.

† Near Santa Fe de Bogota, this formation of *muriatiferous clay*, long neglected in the systems of geognosy, characterizes the gem salt more than the ancient secondary gypsum (aelterer Flozgyps) which reposes on the *zechstein*, or Alpine calcareous stone, as I have shown in 1798, in my work on the *Moffettes of the Mines*. (Ueber die unterirdischen Gasarten, p. 143.)

and friable ; but it encloses more solid masses of a blackish brown, of a schistose, and sometimes conchoidal fracture. These fragments, from six to eight inches long, have an angular form. When they are very small, they give the clay a porphyroidal appearance. We find disseminated in it, as we have already observed, either in nests, or in small veins, selenite, and sometimes, though seldom, fibrous gypsum. It is remarkable enough, that this stratum of clay, as well as the banks of pure gem salt and the *salzthon* in Europe, scarcely ever contain shells, while the rocks adjacent offer them in great abundance.

Although the muriat of soda is not found visible to the eye in the clay of Araya, we cannot doubt of it's existence. It discovers itself in large crystals, if we sprinkle the mass with rain water, and expose it to the Sun. The mere to the east of the castle of San Jago exhibits all the phenomena, which have been observed in the salt lakes of Siberia, described by Lepechin, Gmelin, and Pallas. This mere receives however only the rain waters, which filter through the banks of clay, and unite at the lowest point of the peninsula. While the mere served as a salt-work to the Spaniards and the Dutch, it did not communicate with the sea ; at present this communication has been interrupted anew, by placing faggots at the place where the waters of

the ocean had made an irruption in 1726. After great droughts, crystallized and very pure muriat of soda, in masses of three or four cubic feet, are still drawn from time to time from the bottom of the mere. The salt waters of the lake, exposed to the heat of the Sun, evaporate at their surface; crusts of salt, formed in a saturated solution, fall to the bottom: and by the attraction between crystals of a similar nature and form, the crystallized masses daily augment. It is generally observed, that the water is brackish wherever meres are formed in clayey ground. It is true, that for the new salt work, near the battery of Araya, the seawater is received into pits, as in the salt marshes of the south of France; but in the island of Margaretta, near Pampatar, salt is manufactured by employing only fresh water, with which the muriatiferous clay has been lixivated.

We must not confound the salt disseminated in these clayey soils with that contained in the sands of the seashore, which are advantageously worked on the coasts of Normandy\*. These phenomena, considered in a geognostical point of view, have scarcely any thing in common. I have seen muriatiferous clay at the level of the ocean at *Punta Araya*, and at two thousand toises height in the Cordilleras of New Grenada.

\* In the bay of Avranches, and in many other parts of Europe. Chaptal, *Chimie appliquée aux Arts*, t. iv, p. 161.

If in the former of these spots it lies on a very recent shelly breccia, it forms on the contrary in Austria, near Ischel, a considerable stratum \* in the Alpine lime-stone, which, though equally posterior to the existence of organized beings on the Globe, is nevertheless of high antiquity, as is proved by the great number of rocks with which it is covered. We shall not call in question, that gem salt, either pure † or mixed with muriatiferous clay ‡, may have been deposited by an ancient sea; but every thing evinces, that it was formed during an order of things, that bears no resemblance to that in which the sea at present, by a slower operation, deposits a few particles of muriat of soda on the sands of our shores. In the same manner as sulphur and coal belong to periods of formation very remote from each other, the gem salt is also found sometimes in *transition gypsum* §, sometimes in the *Alpine* lime-stone ||, sometimes in a muriatiferous clay lying on a very recent sand-stone ¶,

\* Buch. Geognost. Beobachtungen, t. i, p. 133.

† Those of Wieliczka and of Peru.

‡ That of Hallein, Ischl, and Zipaquira.

§ Uebergangsgyps, in the transition slate of White Alley [l'Allé Blanche], and between the granwacke and black transition lime-stone near Bex, below the Dent de Chamossaire, according to Mr. von Buch.

|| At Hall in the Tyrol.

¶ At Punta Araya.



and lastly, sometimes in a *gypsum* \* posterior to the chalk.

\* Gypsum of the third formation among the *secondary gypsums*. The *first* formation contains the gypsum, in which are found the brine-springs of Thuringia, and which is placed either in the Alpine lime-stone or *zechstein*, to which it essentially belongs (Freiesleben, Geognost. Arbeiten, t. ii, p. 121.) or between the *zechstein* and the lime-stone of the Jura, or between the *zechstein* and the new sand-stone. It is the ancient gypsum of secondary formation of Werner's school (*aelterer floezgyps*), which we almost preferably call *muriatiferous gypsum*. The *second* formation is composed of fibrous gypsum, placed either in the *molasse*, or new sand-stone, or between this and the upper lime-stone. It abounds in common clay, which differs essentially from the *salzthon* or *muriatiferous clay*. The *third* formation of gypsum is more recent than chalk. To this belong the *bony gypsum of Paris*; and, as appears from the researches of Mr. Steffens (Geogn. Aufsätze, 1810, p. 142), the gypsum of Segeberg, in Holstein, in which gem salt is sometimes disseminated in very small nests (Jenaische Litteratur-zeitung, 1813, p. 100). The gypsum of Paris, lying between a *cerite* lime-stone, which covers chalk, and a sand-stone without shells, is distinguished by fossile bones of quadrupedes, while the Segeberg and Lünebourg gypsums, the position of which is more uncertain, are characterized by the *boracits* which they contain. Two other formations, far anterior to the three we have just mentioned, are the transition gypsum (*uebergangsgyps*) of Aigle, and the primitive gypsum (*urgyps*) of the valley of Canaria, near Airolo. I flatter myself, that I may render some service to the small number of geologists, who prefer the knowledge of positive facts to speculation on the origin of things, in furnishing them with materials, from which they may generalize their ideas on the formation of the rocks in both hemi-

The new salt works of Araya have five reservoirs, or pits, the largest of which have a regular form, and two thousand three hundred square toises surface. Their mean depth is eight inches. Use is made both of the rain waters, which, by filtration collect at the lowest part of the plain, and of the water of the sea, which enters by canals, or *martellières*, when the flood tide is favoured by the winds. The situation of these salt works is less advantageous, than that of the mere. The waters which fall into the latter pass over steeper slopes, washing a greater extent of ground. The natives make use of hand pumps to convey the seawater from one principal reservoir into the pits. It would nevertheless be easy enough to employ the wind as the moving power, since the breeze always blows strong on these coasts. The earth already washed is never carried away here, as is the custom from time to time in the island of Margaretta; nor have wells been dug in the muriatiferous clay, to find strata richer in muriat of soda. The saltmen generally complain of want of rain; and in the new salt works it appears to me difficult to determine, what is the quantity

spheres. The *relative antiquity of the formations* is the principal object of a science, which is to render us acquainted with the *construction of the Globe*; that is to say, the nature and superposition of the stony strata, which constitute the *exterior crust of our planet*.

of salt, that is owing solely to the waters of the sea. The natives estimate it at a sixth of the total produce. The evaporation is extremely strong, and favoured by the constant motion of the air; so that the salt is collected in eighteen or twenty days after the pits are filled. We found\* the temperature of the salt water in the pits  $32.5^{\circ}$ , while the air in the shade was  $27.2^{\circ}$ , and the sand on the coast at six inches depth,  $42.5^{\circ}$ . We were surprised to see, that the thermometer plunged into the sea rose only to  $23.1^{\circ}$ . This low temperature † is owing perhaps to the shoals, which surround the peninsula of Araya, and the island of Margareta, and on the edges of which the lower strata of water mix with the waters of the surface.

Though the muriat of soda is manufactured with less care in the peninsula of Araya than at the salt works of Europe, it is nevertheless purer, and contains less of earthy muriats and sulphats. We are ignorant whether this purity may be attributed to the part of the salt which is furnished by the sea; for though it is extremely probable, that the quantity of the salt dissolved in the waters of the ocean is nearly the same ‡

\* The 19th of August, 1799, at three in the morning.

† See above, page 144.

‡ With the exception of the Mediterranean seas, and the regions where the polar ices are formed. See above, p. 129, 130; and vol. i, p. 64. This equality in the saltiness of the

under every zone, it is not less uncertain, whether the proportion between the muriat of soda, the muriat and sulphat of magnesia, and the sulphat and carbonat of lime be equally invariable\*.

After having examined the salt works, and terminated our geodesical operations, we departed at the decline of day to sleep at an Indian hut, at some miles distance, near the ruins of the castle of Araya. We were preceded by our instruments and provision; for fatigued by the excessive heat of the air, and the reverberation of the soil, we felt no appetite in those climates, except in the morning, or in the cool of the evening. Directing our course toward the south, we traversed first the plain covered with muriatiferous clay, and stripped of vegetation; then two chains of hills of sandstone, between

seawater (from 0.024 to 0.028) reminds us of the still greater uniformity, with which the oxygen is diffused throughout the aërial ocean. In both of these elements, the currents establish and preserve the equilibrium between the parts dissolved or mingled with each other. (Bayly and Cook, *Original Observ.*, p. 345.)

\* Lavoisier found, that in the waters of the sea, near Dieppe, the quantity of muriat of soda is to that of the other salts as 2.36 is to 1. According to Messrs. Bouillon-Lagrange and Vogel, this proportion is as 2.60 to 1. See the judicious observations of Dr. Thomson, in his *Chemistry*, t. vi, p. 346—457. (Henry, *Phil. Trans.*, 1810, p. 97 and 122; and *Annales de Chémie*, t. lxxxvii, p 193—208.)



which is the mere or laguna. Night overtook us while we were in a narrow path, bordered on one side by the sea, and on the other by a range of perpendicular rocks. The tide was rising rapidly, and narrowed the road at every step. We at length arrived at the foot of the old castle of Araya, where we enjoyed a prospect that had in it something lugubrious and romantic. Here however, neither the coolness of a deep and gloomy forest, nor the grandeur of the vegetable forms, heightens the beauty of these ruins ; which, standing single on a bare and arid mountain, crowned with agave, with columnar cactus, and thorny mimosas, resemble less the works of man, than those masses of rock that were ruptured at the first revolutions of the Globe.

We were desirous of stopping to admire this majestic spectacle, and observe the setting of Venus, the disk of which appeared at intervals between the yawning crannies of the castle ; but the muleteer, our guide, was parched with thirst, and pressed us earnestly to return. He had long perceived, that we had lost our way ; and as he hoped to work on our fears, he continually warned us of the danger from tigers and rattlesnakes. Venomous reptiles were in fact very common near the castle of Araya ; and two jaguars had been lately killed at the entrance of the village of Maniquarez. If we might judge from their skins, which had been preserved, their size was not less



than that of the Indian tiger. We vainly represented to our guide, that those animals did not attack men, on coasts where the goats furnished them with abundant food; we were obliged to yield, and return. After having proceeded three quarters of an hour along a shore covered by the tide, we were joined by the negro, who carried our provision. Uneasy at not seeing us arrive, he was come to meet us, and led us across a wood of nopals to a hut inhabited by an Indian family. We were received with that cordial hospitality, which is met with in this country among people of every tribe. The hut in which we slung our hammocks was very clean; and there we found fish, plantains, and what in the torrid zone is preferable to the most sumptuous food, excellent water.

The next day at sunrise, we found, that the hut in which we had passed the night formed part of a group of small dwellings on the borders of the salt lake, the remains of a considerable village which had formerly stood near the castle. The ruins of a church appeared buried in the sand, and covered with brushwood. When in 1765, to save the expence of the garrison, the castle of Araya was totally dismantled, the Indians and Mulattoes, who were settled in the neighbourhood, emigrated by degrees to reside at Maniquarez, at Cariaco, and in the suburb of the Guayquerias at Cumana. A small number,

bound from affection to their native soil, remained in this wild and barren spot. These poor people live by catching fish, which is extremely abundant on the coast and the neighbouring shoals. They appear satisfied with their condition, and think it strange when they are asked why they have no gardens or culinary vegetables. Our gardens, they reply, are beyond the gulf; when we carry our fish to Cumana, we bring back plantains, cocoa nuts, and cassava. This system of economy, grateful to idleness, is followed at Maniquarez, and throughout the whole peninsula of Araya. The chief wealth of the inhabitants consists in goats, which are of a very large and very fine breed, and rove in the fields like those at the Peak of Teneriffe: they are become entirely wild, and are marked like the mules, because it would be difficult to recognize them from their physiognomy, their color, or the disposition of their spots. The wild goats are of a brownish yellow, and are not varied in their color like domestic animals. If in hunting a colonist kills a goat, which he does not consider as his own property, he carries it immediately to the neighbour, to whom it belongs. During two days we heard it every where spoken of as an example of strange perverseness, that an inhabitant of Maniquarez had lost a goat, on which it was probable that a neighbouring family had regaled themselves. These traits, which are

proofs of a great purity of morals in the lower class, are often exhibited in New Mexico, in Canada, and in the countries situate to the west of the Alleghanies.

Among the Mulattoes, whose huts surround the salt-lake, we found a shoemaker of Castilian descent. He received us with the air of gravity and selfsufficiency, which in those climates characterize almost all who are conscious of possessing some peculiar talent. He was employed in stretching the string of his bow, and sharpening his arrows to kill birds. His trade of a shoemaker could not be very lucrative in a country, where the greater part of the inhabitants go bare-foot ; and he only complained, that, on account of the dearness of European gunpowder, a man of his quality was reduced to employ the same weapons as the Indians. He was the sage of the plain, he understood the formation of the salt by the influence of the Sun and the full Moon, the symptoms of earthquakes, the marks by which mines of gold and silver are discovered, and the medicinal plants, which he divided, like all the other colonists from Chili to California, into *hot and cold* \*. Having collected the traditions of the country, he gave us some curious accounts of the pearls of Cubagua, objects of luxury, which he treated with the utmost contempt.

\* Exciting or debilitating, sthenic or asthenic of Brown's system.

To show us how familiar to him were the sacred writings, he took a pride in quoting to us Job, who preferred wisdom to all the pearls of the Indies. His philosophy was circumscribed to the narrow circle of the wants of life. A very strong ass, able to carry a heavy load of plantains to the *embarcadere*, was the object of all his wishes.

After a long discourse on the emptiness of human grandeur, he drew from a leathern pouch a few very small and opake pearls, which he forced us to accept, enjoining us at the same time to note on our tablets, that a poor shoemaker of Araya, but a white man, and of noble Castilian race, had been enabled to give us what on the other side of the sea \* was sought for as a very precious thing. I acquit myself rather late of the promise I made this honest man ; and I am happy to add, that his disinterestedness did not permit him to accept of the slightest retribution. The *Pearl Coast* presents, it is true, the same aspect of misery as the countries of *gold and diamonds*, Choco and Brasil ; but misery is not there attended with that immoderate desire of gain, which is excited by mineral riches.

The *pearl aronde* (*avicula margaritifera*, Cu-

\* *Por alla, or, del otro lado del charco* (properly, "beyond the great mere"), a figurative expression, by which the people in the Spanish colonies denote Europe.

vier) abounds on the shoals, which extend from Cape Paria to that of Vela\*. The island of Margaretta, Cubagua, Coche, Punta Araya, and the mouth of the Rio la Hacha, were celebrated in the sixteenth century, as the Persian Gulf, and the island Taprobane were among the ancients†. It is not just to say, as several historians have asserted, that the natives of America were unacquainted with the luxury of pearls. The first Spaniards who landed in Terra Firma found the savages decked with necklaces and bracelets; and among the civilized people of Mexico and Peru pearls of a beautiful form were extremely sought after. I have published a dissertation on the statue of a Mexican priestess in basalt‡, whose head-dress, resembling the *calantica* of the heads of Isis, is ornamented with pearls. Las Casas and Benzoni have described, but not without some exaggeration, the cruelties which

\* Costa de las Perlas, Herera, Dec. 1, lib. vii, c. 9. Gomara, Hist. c. 78. Petri Bembi Cardin. Hist. Venetæ lib. xii (1555), p. 83. Cancellieri, Diss. sopra Christ. Columbo (1809), p. 101.

† Strabo, lib. xv (pag. Oxon. 1017). Plin., lib. ix, c. 35. lib. xii, c. 18. Solin. Polyhist. c. 66 (ed. 1518, p. 316 and 324), and above all Athen. Deipnosoph. lib. iii, c. 45 (ed. Schweighæuser, 1801, t. i, p. 360—367), and Animadvers. in Athen. t. ii, p. 126.

‡ Picturesque Atlas, pl. 1, and 2. [See vol. xiii of this edition, p. 43.]



were exercised on the unhappy Indian slaves and negroes employed in the pearl fishery. At the beginning of the conquest, the island of Coche alone furnished the value of fifteen hundred marks of pearls a month.

The *quint*, which the king's officers drew from the produce of pearls, amounted to fifteen thousand ducats; which, according to the value of the metals in those times, and the extensiveness of the contraband trade, might be considered as a very considerable sum. It appears, that till 1530 the value of the pearls sent to Europe amounted yearly on an average to more than eight hundred thousand piastres. In order to judge of the importance of this branch of commerce to Seville, Toledo, Antwerp, and Genoa, we should recollect, that at the same period the whole of the mines of America \* did not furnish two millions of piastres; and that the fleet of Ovando seemed to be of immense wealth, because it contained nearly two thousand six hundred marks of silver. Pearls were so much the more sought after, as the luxury of Asia had been in-

\* I have endeavoured to prove in another place (Nouv. Esp. t. ii, p. 652), by a history at large of the ancient mines of Mexico and Peru, the accuracy of the ideas spread throughout Europe on the exhausted state of the metalliferous mines of America, on their deceasing richness, and on the quantity of metals which Spain received during the reigns of Charles the fifth and Philip the second.

roduced into Europe by two ways diametrically opposite; that of Constantinople, where the Paleologi wore garments covered with strings of pearls; and that of Grenada, the residence of the Moorish kings, who displayed at their court all the luxury of the East. The pearls of the East Indies were preferred to those of the West; but the number of the latter which circulated in commerce was not less considerable in the times which immediately followed the discovery of America. In Italy as well as in Spain, the islet of Cubagua became the object of numerous mercantile speculations.

Benzoni \* relates the adventure of one Lewis Lampagnano, to whom Charles the Fifth granted the privilege of proceeding with five carvels to the coasts of Cumana, to fish for pearls. The colonists sent him back with this bold answer: "That the Emperor, too liberal of what was not his own, had not the right to dispose of the oysters, which live at the bottom of the sea."

The pearl fishery diminished rapidly toward the end of the sixteenth century; and, according to Laet, it had long ceased in 1683 †. The in-

\* La Hist. del Mondo Nuovo, p. 34. Lewis Lampagnano, a relation of the assassin of the Duke of Milan, Galeazzo Maria Sforza, could not pay the merchants of Seville, who had advanced the money for his voyage; he remained five years at Cubagua, and died in a fit of insanity.

† "Insularum Cubaguæ et Coches quondam magna fuit

dustry of the Venetians, who imitated fine pearls with great exactness, and the frequent use of cut diamonds \*, rendered the fisheries of Cubagua less lucrative. At the same time the oysters which yielded the pearls became scarcer, not, as it is believed from a popular tradition, because these animals, frightened by the noise of the oars, conveyed themselves elsewhere; but because their propagation had been prevented from the imprudent destruction of the shells by thousands. The *pearla ronde* is of a much more delicate constitution than the greater part of the other acephalous molluscæ. At the isle of Ceylon, where, in the bay of Condeatchy, the fishery employs six hundred divers, and where the annual produce is more than half a million of piastres, it has vainly been attempted to transplant the animals to other parts of the coast. The government permits fishing there only during a single month; while at Cubagua the bank of shells was fished at all seasons. To form an idea of the destruction of the species caused by

dignitas, quum unionum captura floreret: nunc, illa deficiente, obscura admodum fama." Læt. Nov. Orbis, p. 669. This accurate compiler, speaking of Punta Araya, adds, this country is so forgotten, "ut vix ulla alia Americæ meridionalis pars hodie obscurior sit."

\* The cutting of diamonds was invented by Lewis de Berquen, in 1456, but it became common only in the following century.

the divers, we must remember, that a boat sometimes collects, in two or three weeks, more than thirty-five thousand oysters. The animal lives but nine or ten years : and it is only in it's fourth year that the pearls begin to show themselves. In ten thousand shells there is often not a single pearl of value\*. Tradition states, that on the bank of Margaretta the fishermen opened the shells one by one : in the island of Ceylon, the animals are thrown into heaps, to rot in the air ; and to separate the pearls, which are not attached to the shell, the animal pulp is washed, as the miners do the sands that contain grains of gold, tin, or diamonds.

At present Spanish America furnishes no other pearls for trade than those of the gulf of Panama, and the mouth of the Rio de la Hacha. On the shoals that surround Cubagua, Coche, and the island of Margaretta, the fishery is as much neglected as on the coasts of California †. It is believed at Cumana, that the pearl-*aronde* has greatly multiplied after two centuries of repose‡;

\* Cordiner, Description of Ceylon, vol. ii, p. 187.

† Nouv. Esp. t. i, p. 313 : and t. ii, p. 465. I am astonished at never having heard in the course of my travels of pearls found in the fresh water shells of South America, though several species of the *unio* genus abound in the rivers of Peru.

‡ In 1812, some new attempts were made at Margaretta for the fishing of pearls.

and it is asked, why the pearls found at present in shells which are entangled\* in the fishermen's nets are so small, and have so little brilliancy, while on the arrival of the Spaniards they were so extremely beautiful among the Indians, who doubtless had not given themselves the trouble of diving to collect them. The problem is so much the more difficult to solve, as we are ignorant whether earthquakes have altered the nature of the bottom of the sea, or whether the changes of the submarine currents may have had an influence either on the temperature of the water, or on the abundance of certain molluscæ on which the *aronde* feeds.

On the 20th in the morning, our host's son, a young and very robust Indian, conducted us over Barigon and Caney to the village of Maniquarez, which was four hours walk. From the effect of the reverberation of the sands, the thermometer kept up to  $31^{\circ} 3'$ . The cylindric cactus, which bordered the road, gave the landscape an appearance of verdure, without yielding either coolness or shade. Before our guide had travelled a league, he sat himself down at every instant, and wished to repose under the shade of a fine tamarind tree near Casas de la Vela, to wait the approach of the night. I

\* The inhabitants of Araya sometimes sell these small pearls to the retail dealers of Cumana. The ordinary price is a piastre a dozen.



dwell on this characteristic trait, which we observed every time that we travelled with Indians, and has given rise to very false ideas of the physical constitutions of the different races of men. The copper-colored native, more accustomed to the burning heat of the climate, than the European traveller, complains more, because he is stimulated by no interest. Money is without attraction for him ; and if he permits himself to be tempted by gain for a moment, he repents of his resolution as soon as he is on the road. The same Indian, who complains, when in herbalizing we load him with a box filled with plants, rows his canoe fourteen or fifteen hours together, against the swiftest current, because he wishes to return to his family. In order to form a true judgment of the muscular force of the people, we should observe them in circumstances, where their actions are determined by a will equally energetic.

We examined the ruins of San Jago \*, the construction of which is remarkable for its extreme solidity. The walls of free-stone are five feet thick : they have been blown up by mines ; but we still found masses of seven or eight hun-

\* On the map accompanying Robertson's History of America we find the name of this castle confounded with that of Nueva Cordoba. We have already observed, that this latter denomination was formerly synonymous with Cumana. (Herrera, p. 14.)

dred feet square, which have scarcely a crack in them. Our guide showed us a cistern (*el aljibe*) thirty feet deep, which, though much damaged, furnishes water to the inhabitants of the peninsula of Araya. This cistern was finished in 1681, by the governor Don Juan de Padilla Guardiola, the same who built at Cumana the small fort of Santa Maria\*. As the basin is covered with an arched vault, the water, which is of an excellent quality keeps very cool, and has no conferva, which, while it decomposes the carburet of hydrogen, harbours worms and small insects. It had been believed for ages, that the peninsula of Araya was entirely destitute of springs of fresh water; but in 1797, after many useless researches, the inhabitants of Maniquarez succeeded in discovering some.

In crossing the arid hills of Cape Cirial, we perceived a strong smell of petroleum. The wind blew from the side where the springs of this substance are found, and which were mentioned by the first historians of these countries †. Near the village of Maniquarez, the mica-slate ‡ comes out from below the secondary rock, forming a chain of mountains from one hundred and fifty

\* Castillo de Santa Maria, or Fuerte de N. S. de la Cabeza. See above, page 188. (Caulin, p. 284.)

† Oviedo, Lib. 19, cap. 1. "Resinous, aromatic, and medicinal liquor."

‡ Piedra pelada of the Creoles.

to one hundred and eighty toises in height. The direction of the primitive rock near Cape Sotto is from north east to south west ; it's strata incline fifty degrees to the north west \*. The mica-slate is silvery white, of lamellar and undulated texture, and contains garnets. Strata of quartz, the thickness of which varies from three to four toises, traverse the mica-slate, as we may observe in several ravines hollowed out by the waters. We detached with difficulty a fragment of cyanite† from a block of splintered and milky quartz, which was isolated on the shore. This was the only time we found this substance in South America ‡.

The potteries of Maniquarez, celebrated from time immemorial, form a branch of industry, which is exclusively in the hands of the Indian women. The fabrication is still carried on according to the method used before the conquest. It indicates both the infancy of the art, and that stability of manners, which is the characteristic of all the natives of America. Three centuries have been insufficient, to introduce the potter's-wheel on a coast, which is not above thirty or

\* Hours three and four of the Freiberg compass. Very near the village of Maniquarez, the strata vary to hours eleven and twelve, inclining often to the south west.

† Disthène, Haüy.

‡ In New Spain, the cyanite has been discovered only in the province of Guatemala, at Estancia Grande. Del Rio, *Tablas min.*, 1804, p. 27.

forty days sail from Spain. The natives have some confused notions with respect to the existence of this machine, and they would make use of it if they had a model. The quarries whence they draw the clay are half a league to the east of Maniquarez. This clay is produced by the natural decomposition of a mica-slate reddened by oxid of iron. The Indian women prefer the part most abounding in mica ; and with great address fashion vessels two or three feet in diameter, giving them a very regular curve. As they are not acquainted with the use of ovens, they place twigs of *desmanthus*, *cassia*, and the arborescent *capparis*, around the pots, and bake them in the open air. To the east of the quarry that furnishes the clay is the ravine of *la Mina*. It is asserted that, a short time after the conquest, some Venetians extracted gold from the mica-slate. It appears, that this metal was not collected in veins of quartz, but was found disseminated in the rock, as it is sometimes in granite and gneiss.

At Maniquarez we met with some creoles, who had been hunting at Cubagua. Deer of the small breed are so common in this uninhabited islet, that a single person may kill three or four in a day. I know not by what accident these animals have got thither, for Laet and other chroniclers of these countries, speaking of the foundation of New Cadiz, mention only the

great abundance of rabbits. The *venado* of Cubagua belongs to one of those numerous species of small American deer, which zoologists have long confounded under the vague name of *cervus mexicanus*. It does not appear to be the same as the *hind of the savannahs* of Cayenne, or the *guazuti* of Paraguay\*, which live also in herds. Its color is a brownish red on the back, and white under the belly; and it is spotted like the axis. In the plains of Cari, we were shown, as a thing very rare in these burning climates, a variety quite white. It was a female of the size of the roebuck of Europe, and of a very elegant shape. White varieties are found in the New Continent even among the tigers. Mr. d'Azara has seen a jaguar, the skin of which was wholly white, except the shade only, as it might be termed, of a few circular spots.

Of all the productions on the coasts of Araya, that which the people consider as the most extraordinary, we may even say the most marvellous, is the stone of the eyes, *piedra de los ojos*. This calcareous substance is the subject of every conversation; according to the natural philoso-

\* Pennant's Quadrupeds, p. 119, n. 52. Azara, Essay on the Quadrupeds of Paraguay, vol. i, p. 77. Cuvier on the fossile ruminating Animals, in the Ann. du Musée, t. xii, p. 365.



phy of the natives, it is both a stone and an animal. It is found in the sand, where it is motionless ; but placed singly on a polished surface, for instance on a pewter or earthen plate, it moves when excited by lemon juice. Placed in the eye, the pretended animal turns on itself, and expels every other foreign substance, that has been accidentally introduced. At the new salt works, and at the village of Maniquarez, the *stones of the eyes* \* were offered us by hundreds, and the natives were earnest to show us the experiment of the lemon juice. They wished to put sand into our eyes, in order that we might ourselves try the efficacy of the remedy. It was easy to see, that these stones are thin and porous opercula, which have formed part of small univalve shells. Their diameter varies from one to four lines. One of their two surfaces is plane, and the other convex. These calcareous opercula effervesce with lemon juice, and put themselves in motion in proportion as the carbonic acid is disengaged. By the effect of a similar reaction, loaves placed in an oven move sometimes in a horizontal plane ; a phenomenon that has given occasion, in Europe, to the popular prejudice of *enchanted ovens*. The *piedras de los ojos*, introduced into the eye, act like small

\* They are found in the greatest abundance near the battery at the point of Cape Araya.

pearls, and different round grains employed by the American savages to increase the flowing of tears. These explanations were little to the taste of the inhabitants of Araya. Nature has the appearance of greatness to man in proportion as she is veiled in mystery, and the philosophy of the people rejects every thing that bears a character of simplicity.

Proceeding along the southern coast, to the east of Maniquarez, we find running out into the sea very near each other, three strips of land, which bear the names of Punta de Soto, Punta de la Brea, and Punta Guaratarito. In these parts the bottom of the sea is evidently formed of a mica-slate : and it is from this rock, that, near Cape de la Brea \*, but at eighty feet distance from the shore, a spring of naphtha rises, the smell of which spreads itself into the interior of the peninsula. You must wade into the sea up to the waist, to examine this interesting phenomenon. The waters are covered with *zostera* ; and in the midst of a very extensive bank of weeds (*d'herbes*), we distinguish a free and circular spot of three feet diameter, on which swim a few scattered masses of *ulva lactuca*. Here the springs are found. The bottom of the gulf is covered

\* *Tar Cape.* The greatest reservoir of petroleum (*chappote*) is that of the island of Trinidad, which has been described by Span, Hatchet Anderson, and Dauxion Lavaysse. (*Voy. aux Isles de Trinidad et de Tobago*, t. i, p. 24 to 30.)

with sand ; and the petroleum, which, from it's transparency, and it's yellow color, resembles the real naphtha, rises in jets, accompanied by air bubbles. On treading down the bottom with the foot, we perceive, that these little springs change their place. The naphtha covers the surface of the sea to more than a thousand feet distance. If we suppose the dip of the strata to be regular, the mica-slate must be but a few toises below the sand.

We have already observed, that the muriatiferous clay of Araya contains solid and friable petroleum. This geological connection between the muriat of soda and the bitumens is evident wherever there are mines of gem salt or salt springs : but a very remarkable fact is the existence of a fountain of naphtha in a primitive formation. All those hitherto known belong to secondary mountains\* ; and this situation of them seemed to favour the idea, that all mineral bitumens were owing to the destruction of vegetables and animals †, or to the burning of coal. In the peninsula of Araya, the naphtha flows from the primitive rock itself ; and this phenomenon acquires new importance, when we recollect, that the same primitive rocks

\* Pietra mala ; Fanano ; Mont-Zibio ; Amiano, where are the springs that furnish the naphtha employed in lighting the city of Genoa ; Bakou, &c.

† Hatchet, in the Trans. of the Lin. Society, 1798, p. 129.

contain the subterraneous fires, that on the brink of burning craters the smell of petroleum is perceived from time to time, and that the greater part of the hot springs of America rise from gneiss and micaceous schist.

After having examined the environs of Maniquarez, we embarked at night in a fishing boat for Cumana. Nothing is a better proof of the calmness of the sea of these regions, than the extreme smallness and wretched state of these boats, which carry a very high sail. That we chose as the least damaged was so leaky, that the pilot's son was constantly employed in baling out the water with a *tutuma*, or shell of the *crecencia cujete* (calebash). It often happens in the gulf of Cariaco, and especially to the north of the peninsula of Araya, that the canoes loaded with cocoas are upset in sailing too near the wind, and against the waves. These accidents are to be dreaded only by passengers little accustomed to swimming ; for if the canoe be managed by an Indian fisherman and his son, the father sets right the boat and empties it of water, while the son swims about collecting the cocoa nuts. In less than a quarter of an hour, the canoe is again under sail, without a single complaint on the part of the Indian, who meets the accident with calm unshaken indifference.

The inhabitants of Araya, whom we visited a second time on returning from the Oroonoko, did

not forget, that their peninsula was one of the points first peopled by the Spaniards. They love to talk of the pearl fishery ; of the ruins of the castle of St. Jago, which they hope to see some day rebuilt ; and of every thing that recalls to mind the ancient splendour of those countries. In China and Japan those inventions are considered as recent, which have not been known above two thousand years ; in the European colonies an event appears extremely old, if it dates back three centuries, or about the period of the discovery of America.

This absence of memorials, which characterizes new nations, both in the United States, and in the Spanish and Portugueze possessions, is well worthy of attention. The void has not only something painful to the traveller, who finds himself deprived of the most delightful enjoyments of the imagination ; it has also an influence on the greater or less powerful ties, that bind the colonist to the soil on which he dwells, to the form of the rocks surrounding his hut, and to the trees which have shaded his cradle.

Among the ancients, the Phœnicians and the Greeks, for instance, traditions and national remembrances passed from the mother country, to the colonies ; where, perpetuated from generation to generation, they never ceased to have a favorable influence on the opinions, the manners, and the policy of the colonists. The cli-



mates of these first establishments beyond the seas differed but little from those of the mother country. The Greeks of Asia Minor and Sicily were not strangers to the inhabitants of Argos, Athens, and Corinth, from whom they boasted their descent. A great analogy of manners contributed to cement the union, which was founded on religious and political interests. The colonists frequently offered the first fruits of their harvests in the temples of the metropolis : and when by some sinister accident the sacred fire was extinguished on the altars of Hestia, messengers were sent from the farther part of Ionia, to rekindle the flame at the Prytancion of Greece \*. Every where, in Cyrene, as well as on the banks of the Mæotis, the inhabitants carefully preserved the traditions of the mother country. Other remembrances, equally fitted to affect the imagination, were attached to the colonies themselves. They had their sacred groves, their tutelary divinities, their local mythology, and, what gave life and durability to the fictions of the first ages, they had poets, who extended their glory as far as the metropolis itself.

These advantages, and many others, are wanting in modern colonies. The greater part are

\* Clavier, *Hist. des premiers Temps de la Grèce*, t. ii, p. 67. t. i, p. 188.)

settled in a zone, where the climate, the productions, the aspect of the sky, and the scenery of the landscape, differ altogether from those of Europe. The colonist vainly bestows on mountains, rivers, and vallies, those names, which call to his remembrance the sites of the mother country ; these names soon lose their attraction, and have no meaning with the generations that succeed. Under the influence of an exotic nature, habits are generated, that are adapted to new wants ; national remembrances are insensibly effaced ; and those that remain, like phantoms of the imagination, have neither “ a local habitation, nor a name.” The glory of Don Pelagio, and of the Cid Campeador, has penetrated even to the mountains and forests of America ; the people sometimes pronounce these illustrious names ; but they form no other notions of their existence, than that of heroes belonging to some vague period of fabulous times.

This foreign firmament, this contrast of climate, this physical conformation of the country, have a more decided effect on the state of society in the colonies, than the absolute distance of the mother country. Such is the improved state of modern navigation, that the mouths of the Oroonoko and of the Rio de la Plata seem more contiguous to Spain, than in former times Phasis and Tartessus did to the coasts of Greece and Phœnicia. We even observe, that, in re-

gions equally remote, the manners and traditions of Europe are more habitually preserved in the temperate zone, and on the ridges of the equatorial mountains, than in the plains of the torrid zone. Similarity of situation contributes in a certain degree to maintain more intimate connections between the colonists and the metropolis. This influence of physical causes on the state of infant societies is particularly manifested, when it concerns portions of people of the same race, who have been recently separated from each other. In traversing the regions of the New World, we imagine that we find more traditions, a greater freshness in the remembrances of the mother country, wherever the climate permits the cultivation of corn. In this point of view, Pennsylvania, New Mexico, and Chili, resemble those elevated plains of Quito and New Spain, which are covered with oaks and with firs.

Among the ancients, history, religious opinions, and the physical state of a country, were linked together by indissoluble ties. The colonist must have renounced the faith transmitted to him by his ancestors, could he have forgotten the aspect of the sites, and the ancient revolutions of the mother country. With modern nations, religion no longer wears, if I may use the expression, a local tint. Christianity, in furnishing new ideas, and opening a wider range

to the exercise of the intellectual faculties ; in declaring that all nations of men that dwell on the face of the Earth are made of one blood, and members of the same family ; has weakened every exclusive sentiment, and has spread through both Worlds the ancient traditions of the East with those that are peculiarly its own. Nations of different origin, and discordant idioms, have received from this common institution common remembrances ; and the establishment of the missions, after having laid the foundations of civilization in a great part of the New Continent, has given to cosmogonic and religious ideas a marked preeminence over remembrances that were merely national.

But this is not all ; the American colonies are almost all founded in countries, where the generations that are extinct have left scarcely any trace of their existence. At the mouth of the Rio Gila, on the banks of the Missouri, in the plains that extend to the east of the Andes, traditions date no farther back than a century. At Peru, Guatemala, and Mexico, ruins of edifices, historical paintings, and monuments of sculpture, attest, it is true, the ancient civilization of the natives ; but in a whole province we find very few families, who have just ideas relative to the history of the Incas, and of the Mexican princes. The native has preserved his language, his dress, and his national character ; but the



disappearance of the quippus, and of symbolic paintings, the introduction of christianity, and other circumstances, which I have elsewhere developed, have gradually extinguished historical and religious traditions. On the other hand, the colonist of European race disdains whatever relates to the conquered people. Placed between the remembrances of the mother country, and those of the country where he first drew his breath, he considers both with equal indifference ; and in a climate where the equality of seasons renders the succession of years almost imperceptible, he abandons himself to the enjoyments of the present moment, and scarcely casts back a look on the times that are past.

What a difference also between the monotonous history of modern colonies, and the varied picture exhibited by the legislation, the manners, and the political revolutions of the colonies of the ancients ! Their intellectual culture, modified by the different forms of their government, often excited the envy of the mother countries ; and by this happy rivalry arts and letters attained the highest degree of splendor in Ionia, in Græcia Magna, and in Sicily. In our days, on the contrary, the colonies have neither history, nor national literature. Those of the New World have never had powerful neighbours, and there the state of society has undergone only imperceptible changes. Without political exist-



ence, these settlements, formed for commerce or for agriculture, have taken but a passive part in the great agitations of the World. The history of modern colonies affords but two memorable events: their foundation, and their separation from the mother country. The first of these events is rich in remembrances, which essentially belong to the countries occupied by the colonists; but, far from recalling to mind the peaceful progress of industry, or the improvement of colonial legislation, acts of violence and injustice only protrude themselves on the scene. What charm can those extraordinary times present, when, under the reign of Charles the Fifth, the Castilians displayed more courage than virtue? and when chivalrous honour, like the glory of arms, was sullied by fanaticism and the thirst of riches? The colonists, of mild character, are freed by their situation from national prejudices, appreciate at their just value the exploits of the conquest. The men who figured at that period were Europeans; they were the soldiers of the mother country; they appear as strangers to the inhabitants of the colonies, for three ages have been sufficient to dissolve the ties of blood. Among the *conquistadores*, no doubt, some upright and generous men may be found; but, mingled in the mass, they have been unable to escape the general proscription.

I believe, that I have indicated the principal

causes, which in modern colonies have dispelled national remembrances, without nobly filling their place by others relative to the country newly inhabited. This circumstance, we cannot sufficiently repeat, exercises a great influence over the situation of the colonists. In the stormy times of a political regeneration, they find themselves isolated, like a people who, renouncing the study of it's annals, should cease to derive lessons of wisdom from the misfortunes of preceding ages.

END OF VOL. II.

















